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Diesel-Powered Equipment Properties and Activity Database for DoD Off-Road Sources

SERDP Project WP-1338

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ABSTRACT: A database of Department of Defense diesel engine powered off-road equipment was developed using Micro-soft® Access database development tools. The database contains information about fuels, equipment, engines, inventories, usage, and fuel consumption that was obtained from many disparate sources. This database was developed to support the SERDP-funded project Characterization of Off-Road Emissions of Criteria Pollutants (WP-1336). The database was used to prioritize the equipment contained in the WP-1336 test matrix and will later be used as a source of information for the WP-1336 engine emission estimation tool. Data analysis has shown that the top ten fuel consuming engines account for more than 90 percent of fuel usage for the Army and more than 80 percent for the U.S. Marine Corps. Therefore, emission tests performed on a limited number of off-road diesel engines can provide a fairly complete picture of emissions from the entire population of military off-road sources. The database includes an interface that allows users to view data in onscreen forms or analyze data using built-in reports. The database and interface are intended as resources for anyone interested in examining, filtering, querying, or analyzing the collected data.

Executive Summary

Emissions from combat and tactical equipment engines during training activities contribute to local and regional air pollution. The emissions from these Department of Defense (DoD) sources are not well understood, and they will likely differ significantly from the emissions of similar civilian sources. Emission differences are probable because the fuels, vehicle usage patterns, and engine technologies are different. Although many DoD sources are exempt from regulations that limit diesel engine emissions from comparable civilian sources, DoD installations still must be able to answer regulatory questions about the impacts these sources have on air pollution problems. An emissions estimation capability will be useful to installation managers and designers of military training ranges in preventing excessive emissions from off-road sources and developing recommendations for reducing these emissions.

To further the creation of an off-road diesel engine emission estimation capability, the Strategic Environmental Research and Development Program (SERDP) funded the project WP-1336, *Characterization of Off-Road Diesel Emissions of Criteria Pollutants* and WP-1338, which is described in this report. The objective of WP-1338 was to develop a database of DoD off-road sources and their activity. The WP-1338 database was designed to directly support WP-1336 by serving as input during the selection of off-road equipment to be tested. The selection will be based on equipment inventories, usage levels, fuel consumption, and planned future use. Detailed tactical equipment information ensures that the equipment tested represents a larger population of the equipment types. Fuel consumption data allow an estimate of engine use that should correspond better with engine emissions than with other activity measurements such as vehicle miles driven or hours of operation. The database will also be used as a component of the base-wide emissions estimation software tool being developed in WP-1336. The database can serve as a source of equipment characteristics and activity level information that is required by the emission estimation methods used in the software tool.

Another objective of this work was to develop a database that could function independently from the base-wide emission estimation tool mentioned above. This objective was achieved by including a simple user interface that allows onscreen filtering and sorting of data and also allows users to generate reports that group and summarize the data.

To accomplish the project's objectives, researchers (1) collected data on DoD fuels, equipment, diesel engines, and equipment activity, (2) designed and populated a database to store the collected data, (3) developed a user interface, and (4) analyzed data to determine which off-road sources were likely to be major emission contributors. Fuel information was obtained from fuel surveys completed between 1998 and 2003 and performed first by TRW Petroleum Technologies and later by Northrop Grumman Mission Systems. Equipment data were collected from a wide variety of sources including the Federal Logistic (FED LOG) Interactive Database system, technical manuals for equipment; Supply Bulletins listing Army equipment and fuel consumption; a U.S. Air Force equipment database; and the Navy Construction, Automotive and Specialized Equipment Management Information System (CASEMIS). Engine information sources included the FED LOG Interactive Database, equipment technical manuals, and engine manufacturers' Internet sites. The sources of equipment activity and inventory information for this work were the Operating and Support Management Information System (OSMIS) for the Army and the U.S. Marine Corps (USMC) section of the Navy Visibility and Management of Operating and Support Costs (VAMOSC) system. Activity information was collected for Fiscal Years (FY) 2001 through 2003 for both the Army and USMC. References to specific data sources and a more detailed description of the data collection process are included.

The database was designed and developed using Microsoft (MS) Access 2000 since Access is readily available to military personnel as one of the MS Office software applications. The database contains tables for installations, fuels, equipment, engines, and equipment activity and inventory. The tables are linked to one another and referential integrity is activated for each of the relationships in the database so that data integrity will be maintained. The database file containing the originally collected data is encrypted and password protected to prevent this information from being changed so that a baseline of information is maintained. This report gives more details of the overall database design and the design and population of each of the database tables.

The user interface was also developed using MS Access 2000 and is contained in a separate database file. The user interface is a collection of MS Access tables, forms, queries, reports, and Visual Basic for Applications code. The user interface is linked to a temporary database that contains either the originally collected dataset or a dataset previously created by a user. In either case, the temporary database allows the initially opened version of the data to be maintained until the user specifically requests that the dataset be saved to an existing database name or a new file name. However, the interface will not allow the originally collected dataset to be overwritten.

The interface contains individual forms for viewing and editing data from the Installation, Fuels, Engine, Equipment, and Equipment Activity and Inventory tables. Each form uses the same custom toolbar that provides users the ability to sort, search, filter, edit, and navigate data. The interface also contains a report generation form, which allows users to select among several reports and presents options for setting conditions on a selected report. The conditions will vary depending on the report that has been selected, and the conditions default to the most inclusive. The form provides users the choice of previewing the report onscreen or printing it immediately. The form includes reports for engine, equipment, and installation fuel usage with varying degrees of detail.

The report generation feature of the user interface was used to perform preliminary data analysis to determine which off-road diesel-powered sources are likely to be the largest air pollutant emitters. Engine fuel consumption reports were generated for combined Army and USMC use and for individual service use for FY2001 through FY2003 and for just FY2003. The engine fuel usage reports are useful because they tend to group and summarize data from many similar types of equipment that use the same diesel engine. The reports for FY2003 are probably more representative of current usage patterns since FY2003 is the most recent dataset.

The engine fuel consumption reports did show that a relatively small number of engines account for a large percentage of fuel usage with the top ten fuel-consuming engines accounting for over 90 percent of fuel usage for the Army and over 80 percent for the USMC. Therefore, emission tests on a limited number of off-road diesel engines can provide a fairly complete picture of emissions from the entire population of military off-road sources. For vehicles, the High-Mobility Multipurpose Wheeled Vehicle, Heavy Expanded Mobility Tactical Truck, 5-ton trucks, Light Armored Vehicle, Stryker, Family of Medium Tactical Vehicles, and the Bradley Fighting Vehicle all show up as important engine emission sources. M1A1 and M1A2 tanks are also large emissions sources but are powered by a turbine engine that would not likely be classified as a diesel off-road source. Although generator sets are not prominent in combined Army and USMC usage reports, they are artificially underrepresented because Army generator usage is not recorded correctly in OSMIS. The data from the USMC portion of the Navy VAMOSC system indicate that 60-, 30-, and 10-kW generator sets are major engine emission sources, and it is very likely that this same level of usage occurs within the Army and throughout DoD.

Because of the user interface, the database is potentially useful to a wide population that is not necessarily familiar with databases or MS Access. The interface allows database access to anyone interested in obtaining or analyzing data about DoD fuels, off-road equipment, diesel engines, and off-road equipment usage. The data-

base, the interface, and this report are available to anyone with DoD menu privileges in the permanent shared file library section of the Defense Environmental Network and Information Exchange website.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
cubic inches	0.016387	liters
miles (U.S. statute)	1.609347	kilometers
pounds (mass)	0.4535924	kilograms
tons (2,000 pounds, mass)	907.1847	kilograms

*_Système International d'Unités_ ("International System of Measurement"), commonly known as the "metric system."

Preface

This work was conducted for the Strategic Environmental Research and Development Program (SERDP) as Compliance Project WP-1338 "Tailpipe Emission Estimation for DoD Off-Road Sources." The authors thank Dr. Robert W. Holst, SERDP Compliance Program Manager and Bradley P. Smith, SERDP Executive Director, for their support during this program.

The work was performed by the Environmental Processes Branch (CN-E) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL) and the U.S. Army Tank-Automotive Research, Development and Engineering Center, Fuels and Lubricants Research Facility (TFLRF), Southwest Research Institute. The CERL Principal Investigator is Michael R. Kemme. Dr. K. James Hay is Acting Chief, CN-E, and Dr. John T. Bandy is Chief, CN. The associated Technical Director is William D. Severinghaus, CV-T. The Acting Director of CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL James R. Rowan, and the Director of ERDC is Dr. James R. Houston.

Acronyms and Abbreviations

AAV	Assault Amphibian Vehicle
AMDF	Army Master Data File
AOAP	Army Oil Analysis Program
APC	Armored Personnel Carrier
CASEMIS	Construction, Automotive and Specialized Equipment Management Information System
CBS-X	Continuing Balance System – Extract
CDROM	Compact Disc – Read Only Memory
CERL	Construction Engineering Research Laboratory
CONUS	Continental United States
DENIX	Defense Environmental Network and Information Exchange
DMFA	Depot Maintenance Float Allowance
DoD	Department of Defense
DVD	Digital Video Disk
EEAP	Enhanced Equipment Allowance Pool
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
FED LOG	Federal Logistics (Interactive Database)
FLIS	Federal Logistics Information System
FMTV	family of medium tactical vehicles
FORSCOM	U.S. Forces Command
HEMTT	heavy expanded mobility tactical truck
HMMWV	high mobility multi-purpose wheeled vehicle
IAV	interim armored vehicles
LIF	Logistic Integrated Database
LIN	Line Item Number
LOGSA	Logistics Support Activity

MDS	Mission Design Series
MEF	Marine Expeditionary Force
MOB	Mobilization Allowance
MPF	Maritime Prepositioning Force
Net WRMR	Net War Reserve Materiel Requirement
NIIN	National Item Identification Number
NITC	Naval Facility Information Technology Center
OCONUS	outside the Continental United States
O&S	operating and support
OSD	Office of the Secretary of Defense
OSMIS	Operating and Support Management Information System
PMR	Provisioning Master Record
POL	Petroleum, Oils, and Lubricants
PU	power unit
Reserve T/A	Reserve Training Allowance (Pool)
SERDP	Strategic Environmental Research and Development Program
TARDEC	Tank-Automotive Research, Development and Engineering Center
TAMCN	table of authorized material control number
TFLRL	TARDEC Fuels and Lubricants Research Facility
TQG	tactical quiet generator
ULLS-G	Unit Level Logistics System – Ground
USAF	U.S. Air Force
USMC	U.S. Marine Corps
VAMOSC	Visibility and Management of Operating and Support Costs

1 Introduction

Background

Emissions from combat and tactical equipment engines during training activities contribute to local and regional air pollution. The emissions from these Department of Defense (DoD) sources are not well understood, and they likely differ significantly from the emissions of similar civilian sources. Emission differences are probable because the fuels, vehicle usage patterns, and engine technologies are different. Although many DoD sources are exempt from regulations that limit diesel engine emissions from comparable civilian sources, DoD installations still must be able to answer regulatory questions about the impacts these sources have on air pollution problems. For example, the General Conformity provisions of the Clean Air Act require DoD installations to estimate engine emission impacts from combat and tactical equipment after obtaining new missions that include these sources. An emissions estimation capability will also be useful to installation managers and designers of military training ranges in preventing excessive emissions from off-road sources and developing recommendations for reducing these emissions.

In 1998, the U.S. Environmental Protection Agency (EPA) adopted more stringent standards for off-road diesel engines to reduce harmful emissions (63 FR 56968, 23 October 1998). The stricter standards were a response to growing concerns about the contributions these sources make to air pollution problems. Table 1 compares off-road and highway emission contributions to the national emission inventory for 2000 and shows that off-road engines contribute almost as much air pollution as highway engines. Most civilian off-road engines are diesel and virtually all of the military's off-road engines are diesel.

Table 1. Pollutant contributions from highway and off-road engines.

	Emissions (thousands of tons)	
Pollutant	**Highway**	**Off-Road**
Nitrogen oxides	7,988	5,461
Hydrocarbons	3,772	3,677
Carbon monoxide	49,701	29,514
Particulate matter	459	240

Source: EPA 2000.

Air pollutant emissions from off-road sources are currently estimated using the U.S. EPA's NONROAD model. The NONROAD model contains steady-state engine emission factors based on engine power and model year. The emission factors are then adjusted to account for deterioration with age, adjustment for transient-use, and fuel sulfur levels. The NONROAD model estimates emissions of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), particulate matter (PM), nitrogen oxides (NOx), and sulfur dioxide (SO_2). Many of the emission factors are based on data from the 1970s and early 1980s (EPA 1998). NONROAD has been updated recently to correct errors and improve emission estimation for these sources (Craig et al. 2003).

The estimation methods found in NONROAD were developed for civilian sources, however, and the emission estimations from this model and other civilian emission estimation methods will not apply to military off-road sources. Military sources differ from civilian sources in the fuels being used, the usage cycles applied to the compression ignition engines, and the engine technology. These differences are well known to affect emissions from diesel engine powered sources (Clark et al. 2002). The primary fuel used by the military during training is JP-8, which is used almost exclusively as a way of reducing fuel distribution problems in the battlefield and during training scenarios. The occasional exception to JP-8 usage is the use of diesel fuels by some Army National Guard and Reserve units during training. In general, JP-8 has a lower boiling temperature and lower density than diesel fuel. JP-8 also contains corrosion inhibitor, static dissipater, and fuel-system icing inhibitor additives. These fuel differences obviously affect emissions, and a few studies indicate some of these effects (Montalvo and Ullmann 1993; Yost et al. 1996). These effects are not accounted for in current emission estimation methods, however. Military equipment usage is also different than usage of civilian counterparts in the trucking, construction, mining, and agricultural industries. Military activity will vary depending on the type of vehicle and equipment and the type of training. Until these usage patterns are studied and documented, the prediction of military engine emissions will be problematic.

Civilian off-road sources include compression ignition engines used in farm, construction, and industrial equipment. Military sources that fall into the off-road category include tactical/combat vehicles and non-vehicular equipment such as generator sets that use diesel engines. Diesel engine emissions include criteria air pollutants such as PM less than 2.5 micrometers in aerodynamic diameter (PM2.5), PM less than 10 micrometers in aerodynamic diameter (PM10), NOx, SO_2, and CO. Diesel exhaust also contains hundreds of gas-phase, semi-volatile, and particulate-phase organic compounds. Some of these organic emissions are individually listed by regulators as hazardous air pollutants and the California Air Resources Board (ARB) has listed particulate emissions from diesel-fueled engines as a toxic air con-

taminant. Diesel engine emissions have been associated with increased cases of lung cancer and noncancer health effects that impair respiratory function (ARB 1998; EPA 2001).

Objectives

The development of the WP-1338 database described in this report was funded by SERDP to support SERDP project WP-1336, *Characterization of Off-Road Diesel Emissions of Criteria Pollutants.* The objective of this work was to develop a database of DoD off-road sources and their activity. The WP-1338 database directly supports WP-1336 by serving as input during the selection of off-road equipment that will be tested. This selection is based on equipment inventories, usage levels, fuel consumption, and planned future usage. Detailed tactical equipment information ensures that the equipment tested represents a larger population of the equipment type. Fuel consumption data allow an estimate of engine use that should more closely correspond with engine emissions than do other activity measurements such as vehicle miles driven or hours of operation. The database will also be a component of the base-wide emissions estimation software tool being developed in WP-1336. The database can serve as a source of equipment characteristics and activity level information that will be required by the emission estimation methods used in the emission software tool.

Another objective of this work was to develop a database that can function independently from the base-wide emission estimation tool being developed in WP-1336. This objective was achieved by including a simple user interface that allows on-screen filtering and sorting of data and also allows users to generate reports that group and summarize the data.

Approach

The general approach used during this work included the following activities:

Collect data. Data were gathered for fuels, equipment, engines, and activity/inventory of equipment. The U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) Fuels and Lubricants Research Facility (TFLRF) collected information on fuels, equipment and engines and the U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) collected information on equipment inventory and activity. Chapter 2 discusses the major information sources and some data limitations that were encountered.

Design and populate database. CERL was responsible for the database design and population. Microsoft® Access was used to create the database and referential integrity is enforced between related tables to maintain data integrity. Chapter 3 discusses overall database design and the methods used to transfer data into each appropriate data table.

Design and develop user interface. CERL created the user interface for the database. The user interface is a separate MS Access database containing forms, queries, reports, and associated Visual Basic® for Applications code. The user interface database contains linkages to the information database described above. Chapter 4 describes the design and use of the user interface.

Analyze data. CERL used the built-in queries and reports of the user interface to perform some general data analyses and to draw some initial conclusions and inferences from the data analysis results. Chapter 5 summarizes these results in tables and discusses the data analyses.

Mode of Technology Transfer

The primary means of technology transfer has been to provide the database to the investigators working on SERDP project WP-1336. The equipment portion of the database has also been provided to investigators working on SERDP project SI-1195, *Development of a GIS-Based Complex Terrain Model for Atmospheric Dust Dispersion*, as a source of equipment information, such as weight and maximum speed, that is useful in predicting soil-based PM emissions from moving vehicles. The database has also been placed into the permanent shared file library section of the Defense Environmental Network and Information Exchange (DENIX) website, which can be accessed at the following URL:

https://www.denix.osd.mil/denix/DOD/dod.html.

This site is restricted to DENIX users with DoD-level logins and passwords.

This work was published in a peer reviewed conference paper at the annual Air and Waste Management Association 97th Annual Conference and Exhibition in Minneapolis, MN (Kemme 2005). The work was presented as part of the Partners in Environmental Technology Technical Symposium and Workshop in Washington, DC, 29 November–1 December 2005.

This report will also be made accessible through the World Wide Web at the following URLs:

http://docs.serdp-estcp.org/ and

http://www.cecer.army.mil

2 Data Collection

This chapter describes the types of data collected during this project and the sources used to obtain these data. TFLRF researchers collected data for fuels, equipment, and engines, and CERL researchers collected data for equipment activity levels. The different data types were stored in separate spreadsheets in preparation for the consolidation of the data into a database.

Fuels Data

Fuel information was obtained from fuel surveys completed between 1998 and 2003 and performed first by TRW Petroleum Technologies and later by Northrop Grumman Mission Systems (Dickson 1999–2004). The fuel surveys contain chemical and physical information for aviation turbine fuels (Jet A and JP-8), on-road and off-road diesel fuels (1-D and 2-D), and winter and summer grade gasolines. Tables 2 through 8 contain the most recently documented information about these fuels from the fuel survey reports. Only information that was common to all fuel types was included in the database. Since not all the fuel property information is contained in the database, all the collected fuel information is shown in the following tables. The data in these tables are the starting point for that data that were ultimately included in the database. Some of these fuel property data may be shown to be useful for engine emission estimates if specific fuel characteristics are found to impact emission levels.

Table 2. Summarized data for aviation turbine fuels.

Year		2001			2002	
Number of fuels		7			28	
	JP-8			**Jet A**		
Test	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Gravity, °API	37.3	43.1	46	39.6	42.2	46.7
Distillation Temperature:						
10% recovered, °F	333	355	388	341	369	386
50% recovered, °F	375	396	417	368	413	431
90% recovered, °F	455	465	474	410	473	510
Freezing point, °F	-81	-65	-54	-74	-52	-41
Viscosity, kinematic, -4 °F, cSt	3.71	4.59	6.5	3.11	5.28	6.85
Aniline point, °F	134.1	NR	134.1	129.7	139.7	154
Aniline-gravity product No.	5,941	NR	5,941	5,136	5,904	6,405

Year	2001			2002		
Number of fuels	7			28		
	JP-8			Jet A		
Test	Min	Avg	Max	Min	Avg	Max
Acidity, KOH, mg/g	0.001	0.002	0.003	<0.001	0.012	0.03
Sulfur:						
Total, wt.%	0.004	0.033	0.08	<0.001	0.05	0.205
Mercaptan, wt.%	<0.001	<0.001	0.001	<0.001	0.001	0.002
Naphthalenes, vol.%	0.54	1.17	1.6	0.19	1.78	2.7
Aromatic content, vol.%	15	19.8	22.1	12.1	18.6	24.8
Olefin content, vol.%	0.7	1.3	2.6	0	1.5	3.8
Smoke point, mm	19	20.9	25	18	22.3	26
Gum, mg/100ml:						
Existent, at 450 °F	<0.1	0.3	1	<0.1	0.7	6.4
Heat of combustion, net, Btu/lb	18,565		18,565	18,616	18,477	18,605
Thermal stability:						
Pressure drop, mm Hg	<0.1	0.9	3	<0.1	1.2	14
Water separometer index, No.	94	97	98	90	96	99

NR – Not Reported; API – American Petroleum Institute gravity degrees; cSt – centistokes; KOH – potassium hydroxide;

Source: Dickson, April 2003.

Table 3. Summarized national data for 1-D on-highway diesel fuels for 2003.

Number of fuels	3		
	National		
Test	Min	Avg	Max
Gravity, °API	41.4	43.1	44.1
Flash Point, °F	120	138	144
Color, Saybolt chromometer	30	30	30
Viscosity (kinematic), cSt at 104 °F	NR	NR	NR
Cloud point, °F	NR	NR	NR
Pour point, °F	NR	NR	NR
Sulfur content, wt. %	0.002	0.014	0.131
Carbon residue on 10%, wt. %	0.02	0.078	0.12
Ash, wt. %	<0.001	<0.001	<0.001
Cetane number	NR	NR	NR
Cetane index	42.7	46.8	49.2
Aromatics, vol. %	14.2	16.5	21
Distillation temperature, °F			
Initial Boiling Point	285	322	338
10% volume recovered	366	376	380
50% volume recovered	417	418	418
90% volume recovered	453	462	465
End point	480	496	500

NR – Not Reported; API – American Petroleum Institute gravity degrees; cSt – centistokes

Source: Dickson 2004.

Table 4. Summarized 2003 on-highway diesel fuel data for eastern, southern, and central regions.

Number of fuels	21			14			17		
	Eastern Region			Southern Region			Central Region		
Test	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Gravity, °API	31.5	34.5	38.5	31.4	34.5	39	31.4	33.6	36
Flash Point, °F	144	[1]157	190	153	[1]168	179	154	[1]168	190
Viscosity (kinematic), cSt at 104°F	2.28	2.61	3.2	2.44	2.67	3.1	2.35	2.63	3.2
Cloud point, °F	-22	NR	14	-24	NR	14	-22	NR	10
Pour point, °F	-5	NR	10	-30	NR	5	-30	NR	5
Sulfur content, wt. %	0.02	0.037	0.047	0.019	0.034	0.042	0.02	0.034	0.046
Carbon residue on 10%, wt. %	0.05	0.056	0.06	0.04	NR	0.110	0.05	0.107	1.16
Ash, wt. %	0.001	NR	0.001	0.001	NR	0.001	0.001	NR	0.001
Cetane number	41.6	45.8	53.7	41.4	44.7	50.5	40.3	43	46.7
Cetane index	39.1	45	53.2	42.5	45.5	54.9	39.1	43.6	49.3
Aromatics, vol. %	23.1	32.7	40.5	23.6	34.9	43.2	32.2	36.9	39.2
Distillation temperature, °F									
Initial Boiling Point	317	347	397	324	357	398	300	355	398
10% volume recovered	386	409	465	399	415	442	399	418	465
50% volume recovered	487	506	538	498	509	525	485	507	538
90% volume recovered	586	606	627	590	607	628	583	605	634
End point	638	658	675	635	653	668	635	656	683

[1] Median value

NR – Not Reported; API – American Petroleum Institute gravity degrees; cSt – centistokes;
Source: Dickson 2004.

Table 5. Summarized 2003 on-highway 2-D diesel fuel data for the nation and the Rocky Mountain and western regions.

Number of fuels	7			13			72		
	Rocky Mtn Region			Western Region			National		
Test	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Gravity, °API	32.7	34.8	36.3	32.5	36.4	41.2	31.4	34.7	41.2
Flash Point, °F	145	NR	145	144	[1]149	162	144	[1]155	190
Viscosity (kinematic), cSt at 104 °F	2.32	2.55	2.93	2	2.6	3.43	2	2.6	3.43
Cloud point, °F	-22	NR	-10	-22	NR	26	-24	NR	26
Pour point, °F	-25	NR	-25	-25	NR	15	-30	NR	15
Sulfur content, wt. %	0.021	0.034	0.043	0.003	0.023	0.049	0.003	0.033	0.049
Carbon residue on 10%, wt. %	0.11	NR	0.11	0.06	NR	0.11	0.4	0.078	0.16
Ash, wt. %	NR	NR	NR	<0.001	NR	<0.001	<0.001	0.001	0.001
Cetane number	43.1	45.3	47.4	40.3	49.1	55.6	40.3	45.6	55.6
Cetane index	42.8	45	47.5	40	47.3	56	39.1	45.2	56
Aromatics, vol. %	32.7	35.1	38.2	8.9	27.8	40.1	8.9	33.4	43.2
Distillation temperature, °F									
Initial Boiling Point	328	352	376	302	346	396	300	350	398
10% volume recovered	377	407	431	374	403	463	374	410	465
50% volume recovered	484	501	523	437	496	541	437	504	541
90% volume recovered	585	601	610	585	610	624	583	606	634
End point	639	654	668	639	648	693	635	659	693

[1] Median value

NR – Not Reported; API – American Petroleum Institute gravity degrees; cSt – centistokes
Source: Dickson 2004.

Table 6. Summarized 2003 off-highway 2-D diesel fuel data.

Number of fuels	5			8		
	Southern Region			National		
Test	Min	Avg	Max	Min	Avg	Max
Gravity, °API	31.2	34.8	39	31.2	34.2	39
Flash Point, °F	142	156	199	142	[1]162	199
Viscosity (kinematic), cSt at 104 °F	2.1	3.05	4	2.1	3.06	4
Cloud point, °F	-4	NR	22	-4	NR	22
Pour point, °F	-1	NR	15	-10	NR	15
Sulfur content, wt. %	0.2	0.482	1	0.2	0.435	1
Carbon residue on 10%, wt. %	0.001	0.097	0.240	0.001	0.113	0.240
Ash, wt. %	0.001	NR	0.001	0.001	NR	0.001
Cetane number	NR	NR	NR	NR	NR	NR
Cetane index	40.5	48.2	51.8	40.2	46.7	51.8
Aromatics, vol. %	3	NR	3	3	NR	3
Distillation temperature, °F						
Initial Boiling Point	324	368	424	324	371	424
10% volume recovered	390	425	474	390	430	474
50% volume recovered	478	514	556	478	515	556
90% volume recovered	592	612	639	591	613	639
End point	637	651	671	626	652	688

[1] Median value
NR – Not Reported; API – American Petroleum Institute gravity degrees; cSt – centistokes
Source: Dickson, April 2003.

Table 7. Summarized 2002 data for summer motor gasoline grades (averaged analyses results of 551 motor gasoline samples from service stations throughout the United States).

	(R+M)/2 Below 88.0			(R+M)/2 90.0 and Above		
Test	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Gravity, °F	50.3	56.5	61.8	47.8	55.7.	63.6
Sulfur content, wt. %	<0.001	0.027	0.095	0	0.007	0.039
Gum, mg/100 ml	<0.1	<0.1	1	<0.1	<0.1	1
Saturates, vol. %	39.9	54.3	71.9	39.2	58.2	82.1
Olefins, vol. %	0.7	12.5	25.4	0.7	5.9	15.1
Aromatics, vol. %	17	31	42	16.4	31.5	55.4
Benzene, vol. %	0.3	1.15	3.2	0.17	0.77	2.81
Octane number, Research	89.9	92	98.5	93.9	97.5	99.7
Octane number, Motor	81.3	82.6	87.8	85.6	87.5	88.9
Antiknock index, (R+M)/2	85.7	87.3	93.2	90.2	92.5	93.7
Vapor pressure, 100 °F, psi	6.6	7.6	9	6.3	7.6	9
Vapor-liquid ratio of 20, °F	133	147	158	133	151	165
Distillation temperature, °F						
Initial Boiling Point	NR	98	NR	NR	97	NR
5% Evaporated	NR	120	NR	NR	121	NR
10% Evaporated	NR	133	NR	NR	137	NR
20% Evaporated	NR	150	NR	NR	159	NR
30% Evaporated	NR	168	NR	NR	182	NR
50% Evaporated	NR	212	NR	NR	224	NR
70% Evaporated	NR	266	NR	NR	263	NR
90% Evaporated	NR	337	NR	NR	328	NR
95% Evaporated	NR	367	NR	NR	357	NR
End point	NR	415	NR	NR	409	NR
Residue, vol. %	NR	0.6	NR	NR	0.6	NR
Loss, vol. %	NR	1.7	NR	NR	1.8	NR
Ethers, vol. %						
MTBE	<0.1	1	13.3	<0.1	3.7	14.3
TAME	<0.1	0.1	3.6	<0.1	0.2	3.4
ETBE	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
DIPE	<0.1	<0.1	0.1	<0.1	<0.1	0.2

NR – Not Reported
Source: Dickson, March 2003.

Table 8. Summarized 2002 and 2003 data for winter motor gasoline grades (averaged analyses results of 359 motor gasoline samples from service stations throughout the United States).

	(R+M)/2 Below 88.0			(R+M)/2 90.0 and Above		
Test	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Gravity, °F	56.7	61.7	67.2	52.4	59.6	68.1
Sulfur content, wt. %	<0.001	0.029	0.079	<0.001	0.008	0.028
Gum, mg/100 ml	<0.1	1	1	<0.1	1	1
Saturates,vol. %	49.8	61.6	73.1	37.3	62.7	86.1
Olefins, vol. %	1.2	11.7	22.6	1	5.5	19.2
Aromatics, vol. %	18.7	26.2	32.6	11.6	29.5	39.5
Benzene, vol. %	0.46	1.1	2.51	0.14	0.71	2.88
Octane number, Research	89	91.7	93.9	92.7	97.4	100
Octane number, Motor	80	82.7	84.8	85.9	87.8	89.7
Antiknock index, (R+M)/2	84.9	87.2	89.4	90.4	92.6	94.1
Vapor pressure, 100 °F, psi	10.2	13.1	14.7	10.2	13	14.9
Vapor-liquid ratio of 20, °F	108	116	130	110	120	133
Distillation temperature, °F						
Initial Boiling Point	NR	83	NR	NR	83	NR
5% Evaporated	NR	93	NR	NR	94	NR
10% Evaporated	NR	105	NR	NR	107	NR
20% Evaporated	NR	123	NR	NR	130	NR
30% Evaporated	NR	143	NR	NR	159	NR
50% Evaporated	NR	192	NR	NR	215	NR
70% Evaporated	NR	250	NR	NR	258	NR
90% Evaporated	NR	327	NR	NR	321	NR
95% Evaporated	NR	358	NR	NR	349	NR
End point	NR	407	NR	NR	402	NR
Residue, vol. %	NR	0.7	NR	NR	0.7	NR
Loss, vol. %	NR	2.5	NR	NR	2.7	NR
Ethers, vol. %						
MTBE	<0.1	4	11.2	<0.1	2	15.8
TAME	<0.1	<0.1	3	<0.1	0.2	7.2
ETBE	<0.1	<0.1	0.2	<0.1	<0.1	<0.1
DIPE	<0.1	<0.1	0.1	<0.1	<0.1	0.6

Source: Dickson, August 2003.

Equipment Data

The DoD off-road diesel-powered equipment list is comprised of combat, tactical, and ground support equipment found in the U.S. Army, Marine Corps, Air Force, and Navy. The list contains the following types of equipment:

- wheeled vehicles
- tracked vehicles
- generator sets
- power plants
- construction equipment
- material handling equipment.

The EPA definition of off-road diesel-powered equipment excludes equipment that will be used exclusively in a single location. Equipment used in a single location is categorized as a stationary air pollution source, and off-road diesel-powered equipment includes only mobile sources.

Wheeled vehicles, tracked vehicles, and generator sets make up most of the equipment found in the database. Figure 1 shows examples of wheeled vehicles; Figure 2, examples of tracked vehicles; Figure 3, examples of generator sets used in the field.

Figure 1. Examples of wheeled vehicles: top left, a heavy equipment transporter (HET); top right, a heavy expanded mobility tactical truck (HEMTT); bottom left, a high mobility multi-purpose wheeled vehicle (HMMWV); and bottom right, an interim armored vehicle (IAV) also known as the Stryker.

Figure 2. Examples of tracked vehicles: Top left, a Bradley fighting vehicle; top right, an M9 combat earthmover; bottom left, an M88 Hercules recovery vehicle; bottom right, an M113 armored personnel carrier (APC).

Figure 3. Examples of generator sets: Top left, a 3-kW mobile electric power (MEP), tactical quiet generator (TQG); top right, a 30-kW trailer mounted power unit (PU); bottom left, a 200-kW MEP, TQG; bottom right, a 200-kW MEP TQG.

The FED LOG Interactive Database was used to gather equipment information for all four services. The FED LOG Interactive Database is a logistics information system that allows the retrieval of data from the Federal Logistics Information System (FLIS) and service specific databases. The FED LOG Interactive Database was primarily used to gather equipment characteristics data, cross-referencing table of authorized material control number (TAMCN) to national stock number for the USMC equipment, and obtaining nomenclature information for USMC and U.S. Air Force (USAF) equipment. The FED LOG Interactive Database is updated routinely and distributed on CDROM or DVD media. The FED LOG Interactive Database used in this work had an effective date of August 2003.

Another common information source for diesel-powered equipment was technical manuals that describe the maintenance and operation of DoD equipment. These technical manuals were downloaded mainly from Internet sites, and the Internet site used most was https://www.logsa.army.mil/etms/online.htm. The technical manuals were found through searches using the line item numbers, national identification numbers (last nine digits of the equipment national stock number), or equipment nomenclature. The technical manuals were the principal source for equipment data such as weight and fuel consumption.

The Army equipment information came from a variety of sources. The starting point was a TFLRF report that included a listing of U.S. Army fuel-consuming mobility and combat support equipment (TARDEC 1996). The equipment list was updated by adding new equipment and deleting old equipment no longer found in the Army's inventory. The following information sources were used to obtain Army equipment data:

- Chapter 2, of Army Supply Bulletin (SB) 700-20, Army Adopted/Other Items Selected for Authorization/List of Reportable Items
- Chapter 3, SB 710-2, Supply Control: Combat Consumption Rates for Ground and Aviation-Type Petroleum Products
- various Army technical manuals for individual pieces of equipment
- the FED LOG Interactive Database.

SB 700-2 and SB 710-2 provide an updated list of diesel-powered Army equipment and the technical manuals for the individual pieces of equipment and the FED LOG Interactive Database provides more detailed information about this equipment.

The USMC equipment information was collected from the following information sources:

- the Navy Visibility and Management of Operating and Support Cost (VAMOSC) Database (FMB-6 2003)
- Army technical manuals on equipment applicable to the USMC
- the FED LOG Interactive Database.

The VAMOSC management information system collects and reports U.S. Navy and Marine Corps historical weapon system operating and support (O&S) costs. The cost information includes fuel usage information for USMC ground combat systems. For the equipment database, VAMOSC provides a list of USMC equipment that uses diesel fuel, while technical manuals and the FED LOG Interactive Database provide details about each piece of diesel-powered equipment.

The USAF equipment information was collected from the following information sources:

- equipment database from the Warner Robins Air Logistic Center, Support Equipment and Vehicle Directorate
- Army technical manuals on equipment applicable to the USAF
- the FED LOG Interactive Database.

The initial list of USAF equipment came from a spreadsheet containing a database that included diesel-powered equipment from 2002 (Intellimotive Env. Systems 2002). Intellimotive Environmental Systems (Austin, TX) developed the database for the Warner Robins Air Logistics Center, Support Equipment and Vehicle Directorate. The equipment list was expanded by adding diesel-powered equipment that Army technical manuals identified as USAF equipment. Some of the nonvehicular equipment found in the USAF list would not be classified as an off-road source by regulators at many Air Force facilities because the equipment supports aircraft operations and is always used in the same general location.

The U.S. Navy equipment information was collected from the following sources:

- Construction, Automotive and Specialized Equipment Management Information System (CASEMIS)
- Army technical manuals on equipment applicable to the U.S. Navy
- the FED LOG Interactive Database.

The Navy CASEMIS database was obtained from the Naval Facility Information Technology Center (NITC), Seabee Readiness Support Branch, Port Hueneme, CA. The equipment information in the database was from 2002. The equipment list was expanded by adding diesel-powered equipment that Army technical manuals identified as Navy equipment. Just as with USAF equipment, some of the nonvehicular

equipment found in the Navy list would not be classified as an off-road source by regulators at many Navy facilities because the equipment supports port operations and is always used at the same general location.

Engines Data

Engine displacement and horsepower data were collected for each engine with a unique manufacturer and model number. The FED LOG Interactive Database and technical manuals were the primary information sources for the displacement and horsepower data. Also, specific engine manufacturers' (e.g., Detroit Diesel, Cummins, Caterpillar, Onan) Internet sites were consulted to find missing information and as a secondary source for information collected from the FED LOG Interactive Database and technical manuals. In some cases, a specific engine's horsepower output varies with the type of equipment it is powering. When this horsepower variation occurred, the horsepower was averaged so that a single horsepower value was associated with each diesel engine.

Equipment Activity and Inventory

Equipment activity and inventory information is an important component of estimating emissions from the DoD off-road diesel-powered equipment. The EPA's NONROAD model typically calculates engine emissions based partly on either miles driven or hours of operation. A measure of activity that is more directly related to engine emissions is fuel usage. Fuel usage increases with engine size and horsepower while vehicle miles driven and hours of operation do not. If no measure of equipment activity is available, then equipment inventory numbers may provide some insight as to which locations have the largest level of activity.

The sources of equipment activity and inventory information for this work were the Army Operating and Support Management Information System (OSMIS) and the Navy VAMOSC system. These tools are both examples of systems that support DoD policy requiring the explicit consideration of O&S costs from the beginning of the acquisition process throughout the operational life of a program to manage and control these costs. The Office of the Secretary of Defense (OSD) VAMOSC program was established as a means of responding to this requirement. Each service provides information for the DoD VAMOSC program. Although the USAF and Navy VAMOSC systems report on ships, aircraft, missiles, torpedoes, ship systems, and aircraft subsystems, they do not report on the diesel-powered support equipment that might be classified as off-road sources. No other national database of Air Force and Navy activity information was found. Therefore, only Army and Marine Corps

activity information was collected. However, the Army and Marine Corps off-road sources are a large majority of these sources within DoD.

Army Activity Information

OSMIS is the core of the Army portion of the DoD VAMOSC program. OSMIS, managed by the U.S. Army Cost and Economic Analysis Center (USACEAC), is the Army's source of historical O&S cost information for over 1,000 major Army weapon/materiel systems deployed in tactical units belonging to the Active Army, National Guard, and Army Reserve.

The OSMIS Relational Database contains the following commodity group of weapon systems:

- Aviation Systems consisting of rotary and fixed wing aircraft
- Combat Systems consisting of tanks and combat vehicles
- Artillery/Missile Systems consisting of artillery weapons, artillery support vehicles, air defense artillery and missiles, surface-to-surface missiles, and detection systems
- Tactical Systems consisting of wheeled vehicles
- Engineer/Construction Systems consisting of engineer, construction, electrical power generation, and floating equipment
- Communications/Electronics Systems consisting of radio receivers, teletypewriters and terminal sets, switches (voices and message), etc., and communications and data processing systems, radar sets, and terminals, etc.

OSMIS captures data from 30 different data sources throughout the Army, with a large majority of the data coming from Logistics Support Activity (LOGSA). OSMIS was developed under guidance that no new data collection efforts be required of the field. All input data must come from an existing Army database. OSMIS is not a real-time system. OSMIS interfaces with the data sources on a monthly, quarterly, or annual basis. Some of the major data sources used by OSMIS are the Logistic Integrated Database (LIF), the Army Master Data File (AMDF), the Continuing Balance System – Extract (CBS-X), and the Provisioning Master Record (PMR).

Ground activity is captured from the Unit Level Logistics System – Ground (ULLS-G) as the primary source, and Army Oil Analysis Program (AOAP) data as a secondary source. As units use their vehicle systems, the activity of those systems is tracked. Ground vehicle odometers are checked on a regular basis and this information is also fed through an OSMIS process to generate vehicle mileage across the entire Army fleet of vehicles. For aircraft, flight hours are logged and captured through an OSMIS process. Other systems in the Army are tracked only by the number of systems. For systems that consume fuel, fuel consumption is calculated

by multiplying the vehicle activity by the fuel consumption rate. Fuel cost is calculated by multiplying fuel consumption by the unit price of the fuel.

A major end item is known by National Item Identification Number (NIIN) from the Army Master Data File (AMDF). Each OSMIS system is also known by Mission Design Series (MDS) and Army Line Item Number (LIN). A list of OSMIS-approved MDS and MDS Names is kept to ensure that the naming of OSMIS-tracked systems and end items is consistent. For example, while a Bradley Fighting Vehicle may be tracked by NIIN or LIN, the MDS is "M2" and the MDS Name is "Bradley." The OSMIS-approved MDS is not necessarily consistent with federally approved naming conventions because the MDS may have to apply to an entire series of systems. For example, the MDS of a specific type of HMMWV is "M966," and the MDS Name is "HMMWV Series." The primary NIIN indicates which major end item is most commonly used within the entire series of major end items that make up an OSMIS system.

The OSMIS system can be accessed at http://www.osmisweb.com/OSMISWeb/. The system requires a user login available to DoD employees or sponsored contractors. Users access data by first selecting predefined data queries. For this work, the "Fuel Consumption" data query was used, which provides inventory, activity (hours of operation or miles driven), and fuel consumption information. The query interrogates the user through a series of screens to define the data set being requested.

Because of the way the query interrogation screens were structured, a separate query needed to be run for each system that used fuel. A list of fuel consuming equipment was generated by running summary reports listing all Army equipment in OSMIS and looking at the activity basis. Systems that showed an activity basis of "MILES" or "HOURS" indicated that the equipment consumed fuel, and queries were run for each of these systems. For Fiscal Year (FY) 2003, OSMIS reported 222 different equipment systems that consumed fuel. The query results included installations both in the Continental United States (CONUS) and outside CONUS (OCONUS). Since this project's focus was on equipment affected by EPA regulations during training operations, results for installations OCONUS were removed from the data set in a later step. Queries were run for FY2001, 2002, and 2003.

After a query request is run in OSMIS, the results are presented in a tabular form on the screen. To save the results, the page must be saved as a web page file with an ".htm" extension. The file can then be imported into an MS Excel spreadsheet. For this work, separate MS Excel spreadsheet files were created for FY2001, 2002, and 2003 and a separate MS Excel sheet was created for each system. Figure 4 shows example OSMIS data imported into a spreadsheet. The image shows only some of the column headings and a small number of equipment systems.

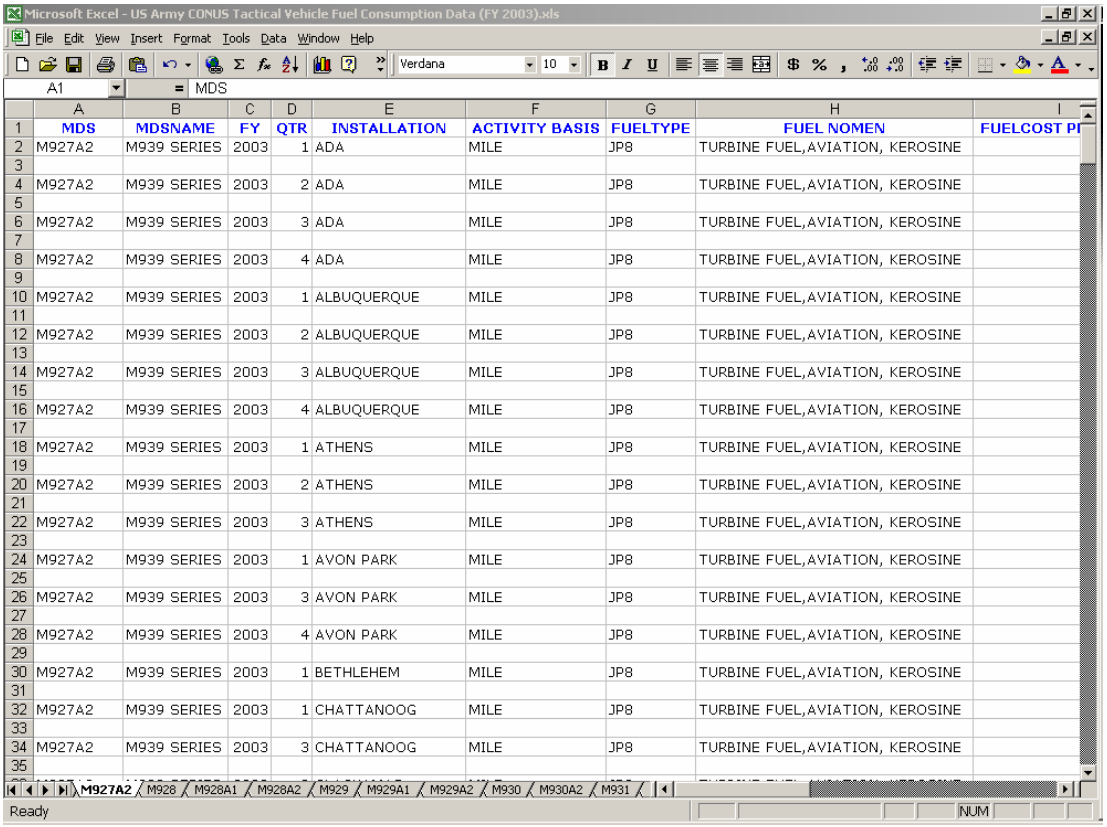


Figure 4. Example of OSMIS data imported into an MS Excel spreadsheet.

The following column headings are included in the OSMIS query results:

- MDS
- MDSNAME
- FY
- QUARTER
- INSTALLATION
- ACTIVITY BASIS
- FUEL TYPE
- FUEL NOMEN
- FUELCOST PER MILE
- ACTIVITY MILES
- FUEL PRICE (Then Years $)
- TOTAL POL COST (Then Years $)
- DENSITY
- FUELCOST PER SYSTEM (Then Years $).

Fuel consumption is not directly reported in the query results, but it can be calculated by dividing the TOTAL POL COST by the FUEL PRICE.

The query results show activity and inventory information by quarter for each location where the equipment is found. Combining all query runs results in a large amount of data. Each fiscal year contained more than 100,000 unique rows (MDS, FY, INSTALLATION) of information. Part of the reason for this is that OSMIS contains information from many small National Guard and Army Reserve facilities.

One of the query interrogation screens asks for a fuel type selection. However, the fuel type information is a bit misleading in that the activity information does not change with different fuel type selections. Instead, the purpose of the fuel type selection is to set a fuel price for cost calculations. Therefore, the total activity and density levels are always reported regardless of which fuel was selected for the query.

The OSMIS data query results showed a problem with most nonaviation activity results presented in hours. Almost all of the query results showed zero or very trivial amounts of activity. Equipment types that had their activity reported in hours included generator sets, forklifts, cranes, and earth/material handling equipment. Only the density numbers give any indication of potential activity for these sources.

Marine Corps Activity Information

The Navy VAMOSC system, briefly described in the **Equipment** section of this chapter, can be accessed at either of these sites: www.navyvamosc.com or http://www.usmcvamosc.com/. Both Internet sites contain a system overview briefing that updates as the system is updated. This report includes information found in the August 2004 FMB-6 briefing.

The Navy VAMOSC system contains information on the following systems:

- Ships Universes
- Aviation Universes
- USMC Ground Equipment
- Weapons
- Personnel Universe.

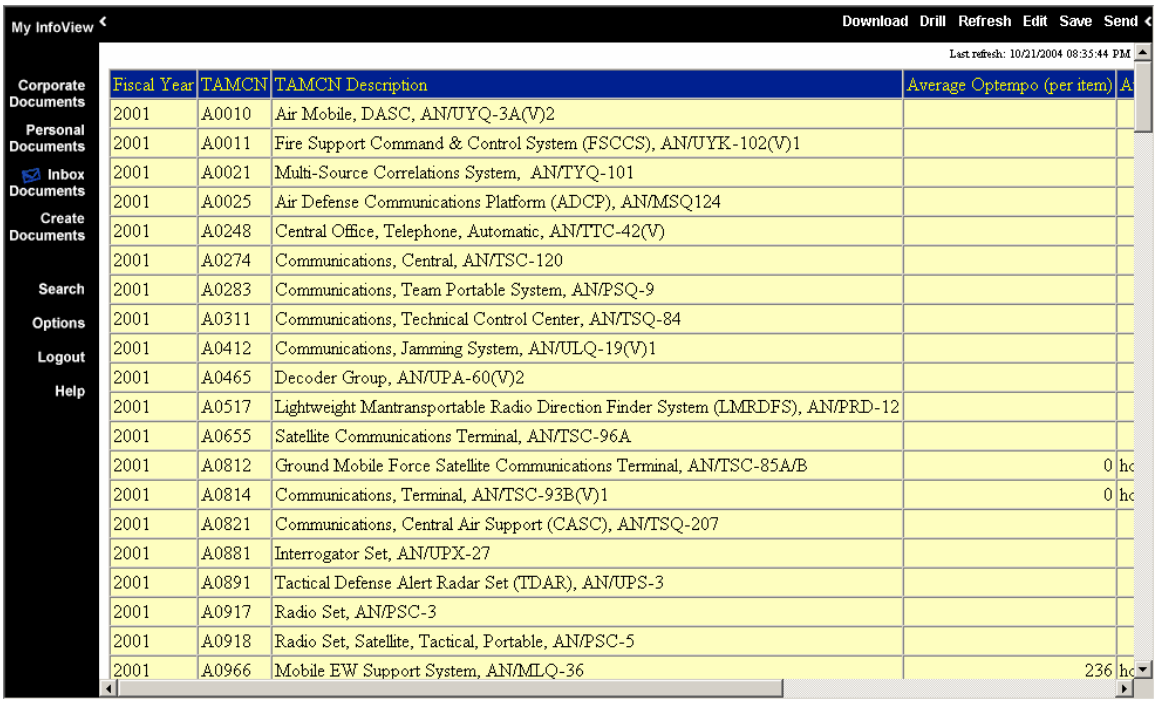
The system uses 133 different data sources, and the information is updated at least annually with historic information dating back to 1984.

The USMC ground equipment component of the system was used for the work reported here. This section of the system tracks individual pieces of equipment by their table of authorized material control number (TAMCN). For FY2003 USMC data, the Navy VAMOSC system increased its coverage from 176 to 343 separate TAMCNs. The following data sources are used to update the USMC information:

- Defense Finance and Accounting Service/Under Secretary of Defense (DFAS/USD) Comptroller
- USMC Logistics Command (LOGCOM)
- Navy Petroleum Office
- Asset Tracking, Logistics and Supply System (ATLASS II+) Program Office
- USMC Systems Command (SYSCOM).

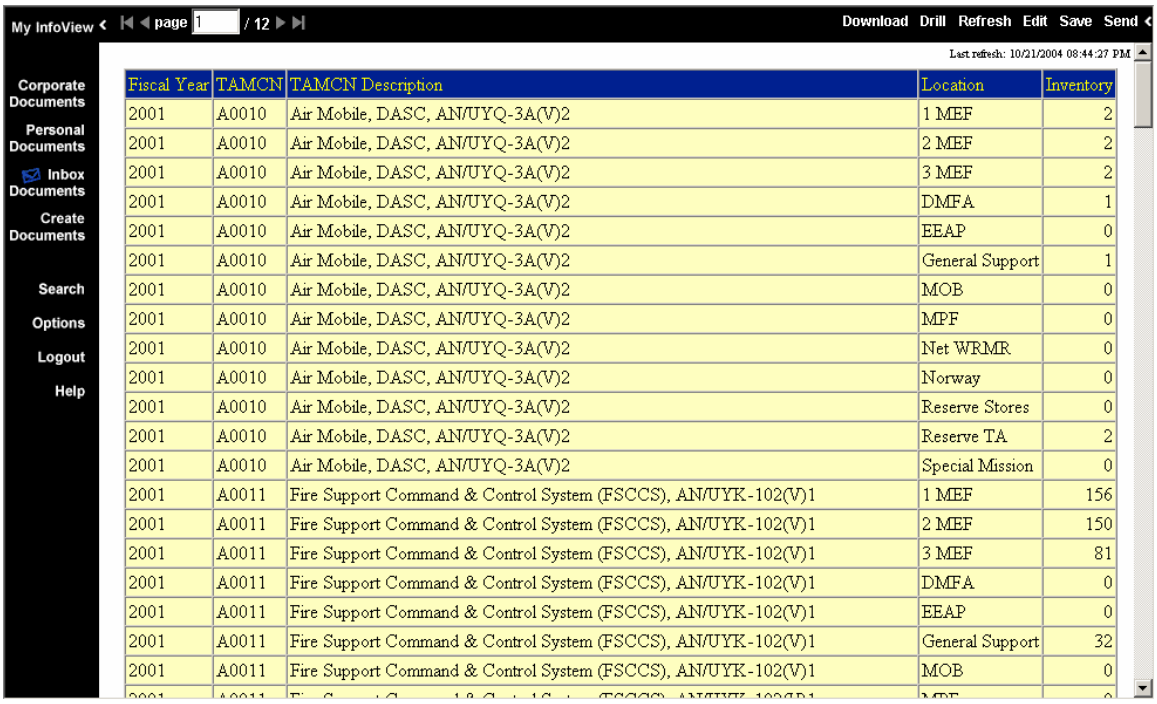
The Navy VAMOSC system allows users to create custom queries from data stored in one of eleven data "universes." For this work, the "USMC Ground Equipment" universe was used. Two separate queries had to be run. The first query contained equipment activity and fuel usage information for all the ground equipment. Figure 5 shows the first page of results from this query. The query contains columns for the fiscal year, TAMCN, TAMCN description, average activity per item, the units for the activity (hours or miles), and the total fuel cost. As Figure 5 shows, not all of the reported equipment uses fuel, with only the very last item on the screen showing a fuel usage. Figure 5 also demonstrates that this query did not report the activity or fuel consumption data by location but provided a summary for all locations. For this reason, a separate query was run to show the inventory of equipment at different locations. Figure 6 shows the first page of results for this new query. The query contains columns for the fiscal year, TAMCN, TAMCN description, location, and inventory. Both of these queries were run for FY2001, 2002, and 2003, and the download feature of the Navy VAMOSC system was used to save the query results into two MS Excel spreadsheet files.

Since a single query could not be designed that would generate activity results by location, the two query results were combined into a single spreadsheet to apportion the summary activity information for individual locations. The first step was the elimination of all equipment that did not report any activity. For activity information, the spreadsheet calculated activity at individual locations by multiplying the average activity per item by the number of items found at a location. For fuel consumption information, the spreadsheet first calculated the total gallons of fuel by dividing the total Petroleum, Oils, and Lubricants (POL) cost by the price of JP-8 fuel for the year the activity was recorded. The POL costs were obtained from the Navy VAMOSC, USMC Ground Equipment User Manual (IBM 2004). The usage for each location was then apportioned by the number of items at a location divided by the total number of items throughout the USMC. The Navy VAMOSC system did not exhibit the same problem as the OSMIS system with regard to reporting activity for equipment when the activity is measured in hours.



Fiscal Year	TAMCN	TAMCN Description	Average Optempo (per item)	A
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2		
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1		
2001	A0021	Multi-Source Correlations System, AN/TYQ-101		
2001	A0025	Air Defense Communications Platform (ADCP), AN/MSQ124		
2001	A0248	Central Office, Telephone, Automatic, AN/TTC-42(V)		
2001	A0274	Communications, Central, AN/TSC-120		
2001	A0283	Communications, Team Portable System, AN/PSQ-9		
2001	A0311	Communications, Technical Control Center, AN/TSQ-84		
2001	A0412	Communications, Jamming System, AN/ULQ-19(V)1		
2001	A0465	Decoder Group, AN/UPA-60(V)2		
2001	A0517	Lightweight Mantransportable Radio Direction Finder System (LMRDFS), AN/PRD-12		
2001	A0655	Satellite Communications Terminal, AN/TSC-96A		
2001	A0812	Ground Mobile Force Satellite Communications Terminal, AN/TSC-85A/B	0	hc
2001	A0814	Communications, Terminal, AN/TSC-93B(V)1	0	hc
2001	A0821	Communications, Central Air Support (CASC), AN/TSQ-207		
2001	A0881	Interrogator Set, AN/UPX-27		
2001	A0891	Tactical Defense Alert Radar Set (TDAR), AN/UPS-3		
2001	A0917	Radio Set, AN/PSC-3		
2001	A0918	Radio Set, Satellite, Tactical, Portable, AN/PSC-5		
2001	A0966	Mobile EW Support System, AN/MLQ-36	236	hc

Figure 5. First page of query results showing activity and fuel usage information from the Navy VAMOSC system.



Fiscal Year	TAMCN	TAMCN Description	Location	Inventory
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	1 MEF	2
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	2 MEF	2
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	3 MEF	2
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	DMFA	1
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	EEAP	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	General Support	1
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	MOB	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	MPF	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	Net WRMR	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	Norway	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	Reserve Stores	0
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	Reserve TA	2
2001	A0010	Air Mobile, DASC, AN/UYQ-3A(V)2	Special Mission	0
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	1 MEF	156
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	2 MEF	150
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	3 MEF	81
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	DMFA	0
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	EEAP	0
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	General Support	32
2001	A0011	Fire Support Command & Control System (FSCCS), AN/UYK-102(V)1	MOB	0

Figure 6. First page of query results showing inventory information from the Navy VAMOSC system.

Summary

For the most part, the data collection objectives of this project were met. Data were collected for fuels, equipment, engines, and equipment activity levels. Equipment and engine information came from many different sources, but the data were consolidated and entered into engine and equipment spreadsheets that contain information from all the services. This information should prove useful to the WP-1336 research group as they develop an emission estimation tool. Equipment activity level information was successfully gathered for the Army and USMC but not for the Air Force and Navy who do not centrally account for the off-road diesel equipment that support aircraft and ships. Therefore, the WP-1336 research group cannot use the activity information to prioritize Air Force and Navy off-road emission sources. However, the inventory of off-road diesel-powered equipment owned by the Air Force and Navy is much smaller than the Army and USMC inventory since their mission is more oriented towards off-road training. The Army and USMC activity data should prove very useful in determining the diesel-powered off-road equipment used most often by these services.

3 Database Design and Population

As mentioned in the **Introduction**, two MS Access databases were developed during this project. This chapter describes the database that stores the information that was collected, and Chapter 4 describes the database that provides a user interface for displaying data and viewing reports on the collected information. Researchers used MS Access 2000 for this work, and earlier versions of Access will not be able to read the database files.

Database information is kept in tables designed to store related data. Tables contain records that are similar to rows in a spreadsheet and fields that are like columns in a spreadsheet. The fields and field names describe the types of data contained in a table and each record stores an individual instance of this data. A table also has a primary key that defines what makes each record unique. The primary key is composed of one or more fields in the table, and the data in the primary key fields are unique for every record in the table.

Overall Structure

The following tables are included in the database:

- Installations
- Fuels
- Equipment
- Engines
- Equipment Activity and Inventory.

Figure 7 is the MS Access relationships diagram that shows the overall design of the database. The diagram shows all the database tables and their relationships with each other. Multiple tables are used in a database to avoid storage of repetitive information that is common to many records in another table. Tables are linked to each other using fields that occur in both tables. For example, the Engines table is linked to the Equipment table using the fields "Engine_Manufacturer" and "Model_Number." The "1" symbol in the diagram indicates the table that contains a single record that is related to many records in the other table of the relationship.

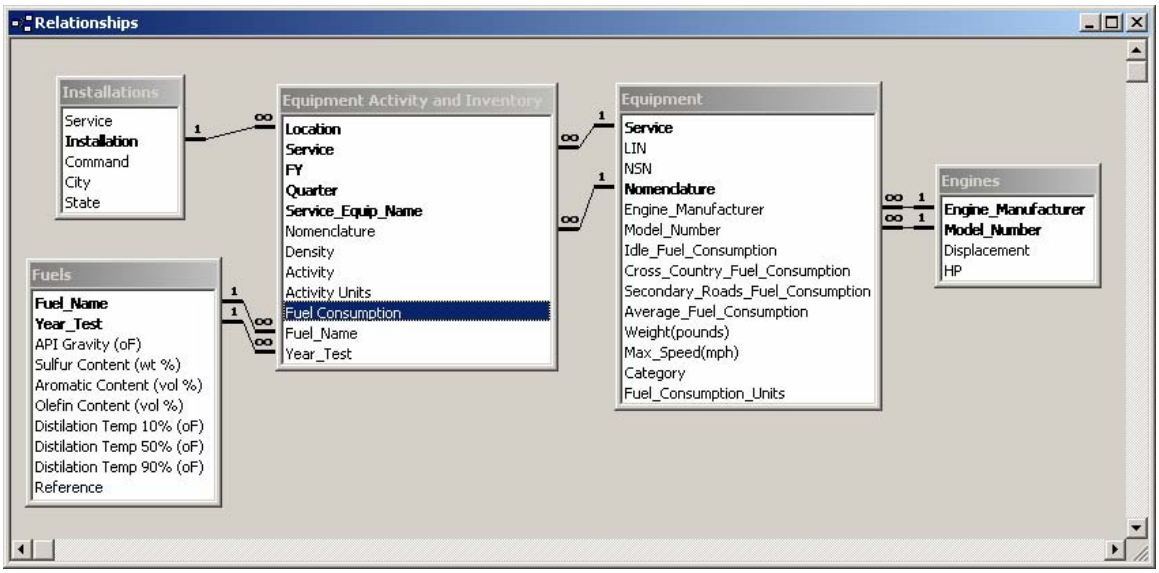
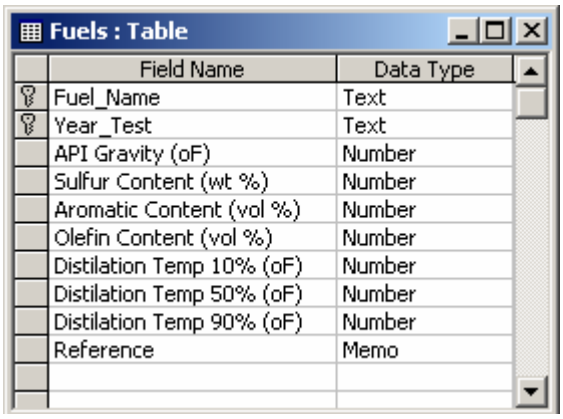


Figure 7. Overall database design.

For all the relationships in the database, referential integrity was enforced and the cascade update feature was activated. Enforcing referential integrity ensures that data remain consistent within the database. Activating the cascade update feature will automatically change the data on the many side of a one-to-many relationship when a datum is changed in one of the linked fields in the table on the one side of the relationship. The cascade delete feature was activated between the Equipment Activity and Inventory table and the Equipment table and between the Equipment table and the Engines table. In this way, if any piece of equipment is deleted, then the associated records in the Equipment Activity and Inventory table are also deleted. If an Engine table record is deleted, then the associated records in the Equipment table are deleted and the Equipment deletions will again cause deletions of associated records in the Equipment Activity and Inventory table.

Fuels Data

The Fuels table in the database includes a subset of the data found in the fuels spreadsheet tables shown in Chapter 2. The fields included in the table were selected because they contain information that is common to all the fuels. Figure 8 shows the Fuels table design screen that lists the field names and data types. When a field contains a numeric property of the fuel, the field name includes the units of that property enclosed in parenthesis at the end of the field name. The fields "Fuel_Name" and "Year_Test" are both included in the primary key because different fuel testing years are included in the table. The "Reference" field contains citations for the fuel testing reports used as data sources for each record.

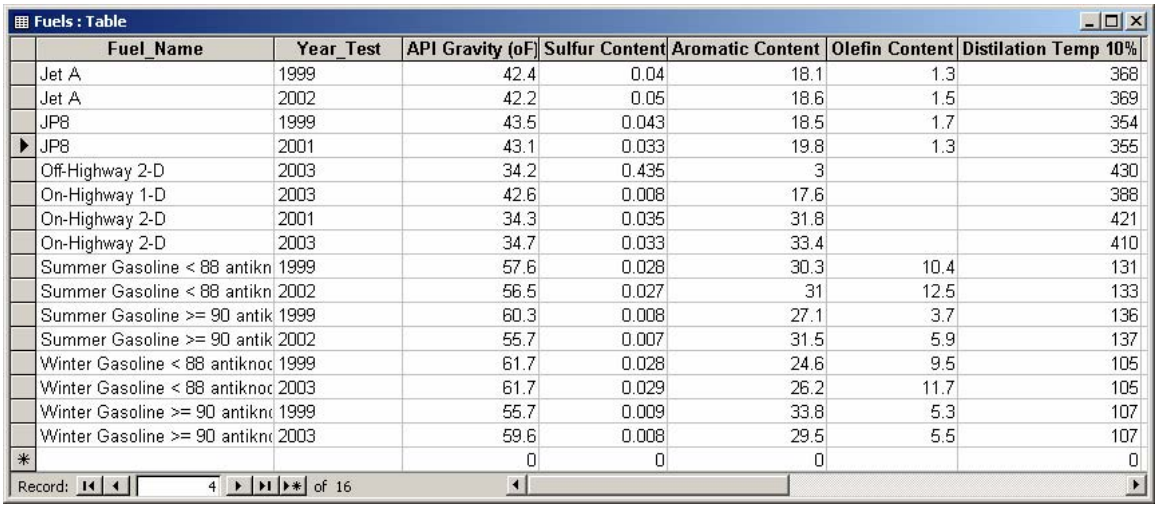


Fuels : Table

	Field Name	Data Type
🔑	Fuel_Name	Text
🔑	Year_Test	Text
	API Gravity (oF)	Number
	Sulfur Content (wt %)	Number
	Aromatic Content (vol %)	Number
	Olefin Content (vol %)	Number
	Distilation Temp 10% (oF)	Number
	Distilation Temp 50% (oF)	Number
	Distilation Temp 90% (oF)	Number
	Reference	Memo

Figure 8. Fuels table design screen.

Figure 9 contains some of the data from the Fuels table. The figure shows all of the records in the table but not all of the fields. Figure 9 illustrates that some fuel types have more than one record because multiple testing years are included in the data set.



Fuels : Table

Fuel_Name	Year_Test	API Gravity (oF)	Sulfur Content	Aromatic Content	Olefin Content	Distilation Temp 10%
Jet A	1999	42.4	0.04	18.1	1.3	368
Jet A	2002	42.2	0.05	18.6	1.5	369
JP8	1999	43.5	0.043	18.5	1.7	354
JP8	2001	43.1	0.033	19.8	1.3	355
Off-Highway 2-D	2003	34.2	0.435	3		430
On-Highway 1-D	2003	42.6	0.008	17.6		388
On-Highway 2-D	2001	34.3	0.035	31.8		421
On-Highway 2-D	2003	34.7	0.033	33.4		410
Summer Gasoline < 88 antikn	1999	57.6	0.028	30.3	10.4	131
Summer Gasoline < 88 antikn	2002	56.5	0.027	31	12.5	133
Summer Gasoline >= 90 antik	1999	60.3	0.008	27.1	3.7	136
Summer Gasoline >= 90 antik	2002	55.7	0.007	31.5	5.9	137
Winter Gasoline < 88 antiknoc	1999	61.7	0.028	24.6	9.5	105
Winter Gasoline < 88 antiknoc	2003	61.7	0.029	26.2	11.7	105
Winter Gasoline >= 90 antikn	1999	55.7	0.009	33.8	5.3	107
Winter Gasoline >= 90 antikn	2003	59.6	0.008	29.5	5.5	107
		0	0	0		0

Record: 4 of 16

Figure 9. Data from the Fuels table.

Equipment Data

The Equipment table in the database contains a list of off-road diesel-powered equipment used by DoD and properties and attributes of this equipment. The fields included in the table either help identify the equipment or contain properties that may be important in predicting engine emissions. Figure 10 shows the Equipment table design screen that lists the field names and data types. When a field contains a numeric property of the fuel, the field name includes the units of that property enclosed in parenthesis at the end of the field name. The exceptions to this are the fields containing fuel consumption information. In this case, the field

"Fuel_Consumption_Units" contains the fuel consumption units that were either km/hr for vehicular equipment or gal/hr for nonvehicular equipment. The fields "Service" and "Nomenclature" both are included in the primary key because the same equipment with the same Nomenclature may be shared by different services. The field "LIN" contains a service-specific identification number while the field "NSN" contains the service independent national stock number. A few records are missing the NSN, LIN, or both the NSN and LIN.

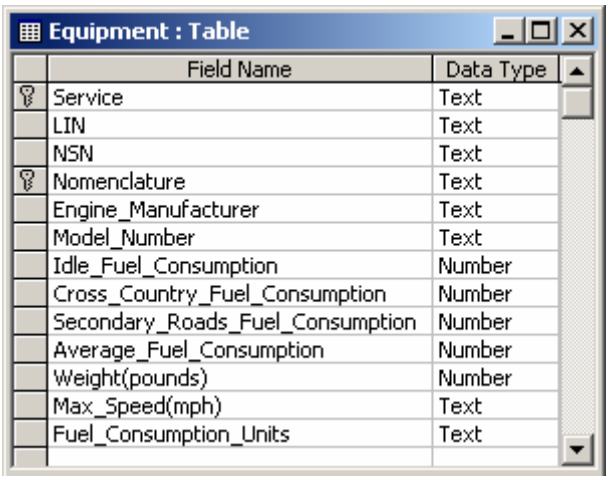


Figure 10. Equipment table design screen.

Figure 11 contains a snapshot of data from the Equipment table. The figure shows records containing data for HEMTT and cargo trucks used by the Army. Figure 11 shows that there are 1,103 records in the Equipment table, which includes equipment with a wide range of introduction dates since the DoD has consistently developed new versions of equipment over time but still uses equipment that was introduced decades earlier.

Equipment : Table

Service	LIN	NSN	Nomenclature	Engine_Manufacturer	Model_Number
USA	X39187	2320000508927	TRUCK BOLSTER 5TON WW M815	CUMMINS ENGINE	NHC 250
USA	T59278	2320010996426	TRUCK CARGO 10TON HEMTT M977	DETROIT DIESEL	8V92TA
USA	T59278	2320014933779	TRUCK CARGO 10TON HEMTT M977A2	DETROIT DIESEL	8V92TA DDEC IV
USA	T59278	2320014933785	TRUCK CARGO 10TON HEMTT M977A2R1	DETROIT DIESEL	8V92TA DDEC IV
USA	T39586	2320011007673	TRUCK CARGO 10TON HEMTT M985	DETROIT DIESEL	8V92TA
USA	T39586	2320014928201	TRUCK CARGO 10TON HEMTT M985A2	DETROIT DIESEL	8V92TA DDEC IV
USA	T39586	2320014933789	TRUCK CARGO 10TON HEMTT M985A2R1	DETROIT DIESEL	8V92TA DDEC IV
USA	T41721	2320011947032	TRUCK CARGO 10TON HEMTT M985E1	DETROIT DIESEL	8V92TA
USA	T41721	2320014933790	TRUCK CARGO 10TON HEMTT M985E1A2	DETROIT DIESEL	8V92TA DDEC IV
USA	T41721	2320014933792	TRUCK CARGO 10TON HEMTT M985E1A2R1	DETROIT DIESEL	8V92TA DDEC IV
USA	T39518	2320010970260	TRUCK CARGO 10TON HEMTT WW M977	DETROIT DIESEL	8V92TA
USA	T39518	2320014933774	TRUCK CARGO 10TON HEMTT WW M977A2	DETROIT DIESEL	8V92TA DDEC IV
USA	T39518	2320014933782	TRUCK CARGO 10TON HEMTT WW M977A2R1	DETROIT DIESEL	8V92TA DDEC IV
USA	T39654	2320010970261	TRUCK CARGO 10TON HEMTT WW M985	DETROIT DIESEL	8V92TA
USA	T39654	2320014928214	TRUCK CARGO 10TON HEMTT WW M985A2	DETROIT DIESEL	8V92TA DDEC IV
USA	T39654	2320014933787	TRUCK CARGO 10TON HEMTT WW M985A2R1	DETROIT DIESEL	8V92TA DDEC IV
USA	X41790	2320007400493	TRUCK CARGO 10TON WW M125A1	CUMMINS ENGINE	V8-300
USA	X40077	2320009260873	TRUCK CARGO 21/2TON D/S M35A2C	CONTINENTAL	LD465-1
USA	X40077	2320013832050	TRUCK CARGO 21/2TON D/S M35A3C	CATERPILLAR	3116 ATAAC
USA	X40214	2320009260875	TRUCK CARGO 21/2TON D/S WW M35A2C	CONTINENTAL	LD465-1
USA	X40214	2320013832049	TRUCK CARGO 21/2TON D/S WW M35A3C	CATERPILLAR	3116 ATAAC
USA	X40283	2320013832048	TRUCK CARGO 21/2TON LWB M36A3	CATERPILLAR	3116 ATAAC
USA	X40420	2320013832046	TRUCK CARGO 21/2TON LWB WW M36A3	CATERPILLAR	3116 ATAAC
USA	X40009	2320005425633	TRUCK CARGO 21/2TON M35A1	CONTINENTAL	LDS465-1
USA	X40009	2320000771616	TRUCK CARGO 21/2TON M35A2	CONTINENTAL	LDS465-1
USA	X40009	2320013832047	TRUCK CARGO 21/2TON M35A3	CATERPILLAR	3116 ATAAC
USA	X40146	2320005425634	TRUCK CARGO 21/2TON WW M35A1	CONTINENTAL	LDS465-1
USA	X40146	2320000771617	TRUCK CARGO 21/2TON WW M35A2	CONTINENTAL	LD465-1
USA	X40146	2320013833850	TRUCK CARGO 21/2TON WW M35A3	CATERPILLAR	3116 ATAAC
USA	X40283	2320000771618	TRUCK CARGO 21/2TON XLWB M36A2	CONTINENTAL	LD465-1

Record: 1 of 1103

Figure 11. Data from the Equipment table.

When the equipment data were collected, it was discovered that some equipment had the same Nomenclature names but different NSNs. It was decided to enter all of these equipment data in case users should want to search for equipment by its NSN. These records are distinguished from one another in the table by adding sequential numbers, starting with one, enclosed in parenthesis at the end of the Nomenclature name. For example, the table includes records with the Nomenclature names "GEN ST DED 10KW 400HZ TQ PU799(1)" and "GEN ST DED 10KW 400HZ TQ PU799(2)" with NSNs of "6115013134283" and "6115014133819."

Some of the records for tracked vehicles in the Equipment table contain fuel consumption rates specified for idle, cross country, and secondary road conditions. In these cases, an average fuel consumption rate was not published and the average fuel consumption value in the table was calculated by averaging the three available fuel consumption values from the Equipment table.

Engine Data

The Engines table in the database contains a list of engines used in DoD off-road diesel-powered equipment. Engine manufacturers and model numbers identify each of the engines. The engine displacements and horsepower are also recorded in the Engine table. Figure 12 shows the Engines table design screen that lists the field names and data types. The engine displacement is measured in cubic inches. The fields "Engine_Manufacturer" and "Model_Number" both are included in the primary key because the same manufacturer often makes several diesel engines used in DoD equipment.

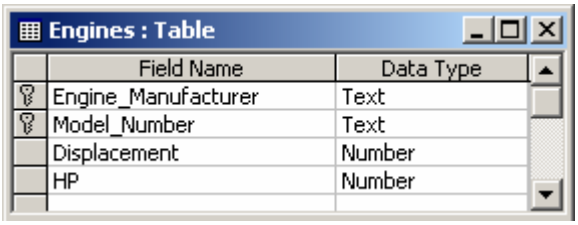


Figure 12. Engines table design screen.

Figure 13 contains a snapshot of data from the Engines table. The figure shows records containing data for engines manufactured by Continental and Cummins Engine. The figure also shows that there are 175 records in the Engines table. Although not shown in Figure 13, a few records are missing the displacement and horsepower information. As mentioned in Chapter 2, some of the horsepower fields contain averages of horsepower values varied by different equipment types that used the same engine.

Engines : Table

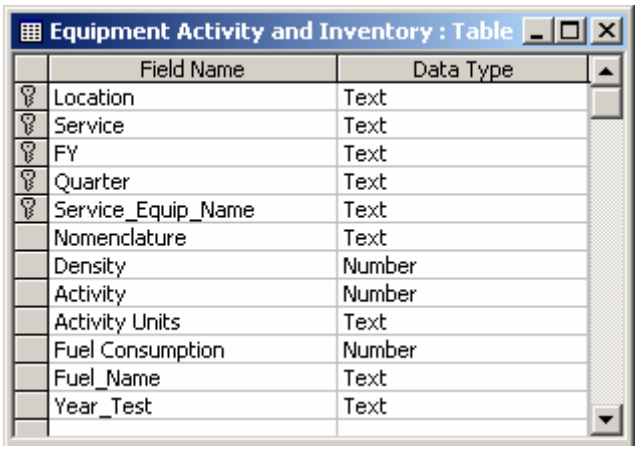
Engine_Manufacturer	Model_Number	Displacement	HP
CONTINENTAL	AVDS1790-2A	1790	783
CONTINENTAL	AVDS1790-2A, D, D	1790	783
CONTINENTAL	AVDS1790-2C	1790	783
CONTINENTAL	AVDS1790-2D	1790	783
CONTINENTAL	AVDS1790-2DA	1790	783
CONTINENTAL	AVDS1790-2DR	1790	783
CONTINENTAL	LD465-1	478	160
CONTINENTAL	LDS465-1	478	160
CONTINENTAL	TMD27	299	101
CUMMINS ENGINE	4B3.9	239	74
CUMMINS ENGINE	6BT5.9	359	152
CUMMINS ENGINE	6BT5.9-C	359	152
CUMMINS ENGINE	6CTA8.3	506	240
CUMMINS ENGINE	C180	300	130
CUMMINS ENGINE	JN-6-I	401	101
CUMMINS ENGINE	KT1150	1150	380
CUMMINS ENGINE	KTA2300G	2300	1235
CUMMINS ENGINE	N855/235	855	235
CUMMINS ENGINE	NHC 250	854	250
CUMMINS ENGINE	NT-380-1	1015	335
CUMMINS ENGINE	NTC 400	855	400
CUMMINS ENGINE	NTTA-855-P450	855	450
CUMMINS ENGINE	QSM 11	661	400
CUMMINS ENGINE	V8 265 2380	785	265
CUMMINS ENGINE	V8-300	785	300
CUMMINS ENGINE	V903C	903	295
CUMMINS ENGINE	VT400	854	400
CUMMINS ENGINE	VTA28G1	1710	750
CUMMINS ENGINE	VTA-903T	903	500
CUMMINS ENGINE	VTA903-T525	903	525

Record: 1 of 175

Figure 13. Data from the Engines table.

Equipment Activity and Inventory Data

The Equipment Activity and Inventory table contains activity information for Army and USMC diesel-powered off-road equipment. The fields describe inventory, activity, and fuel consumption information for equipment used at specific locations over either a quarter (Army) or year (USMC). Figure 14 shows the MS Access Equipment Activity and Inventory table design screen that lists the field names and data types. "Fuel_Consumption" is always reported in gallons, and activity is either reported in miles traveled or hours of operation, with the appropriate units shown in the "Activity Units" field. Since the table records information from varying services, equipment types, and time periods, the primary key is a combination of the "Location," "Service," "FY," "Quarter," and "Service_Equip_Name."

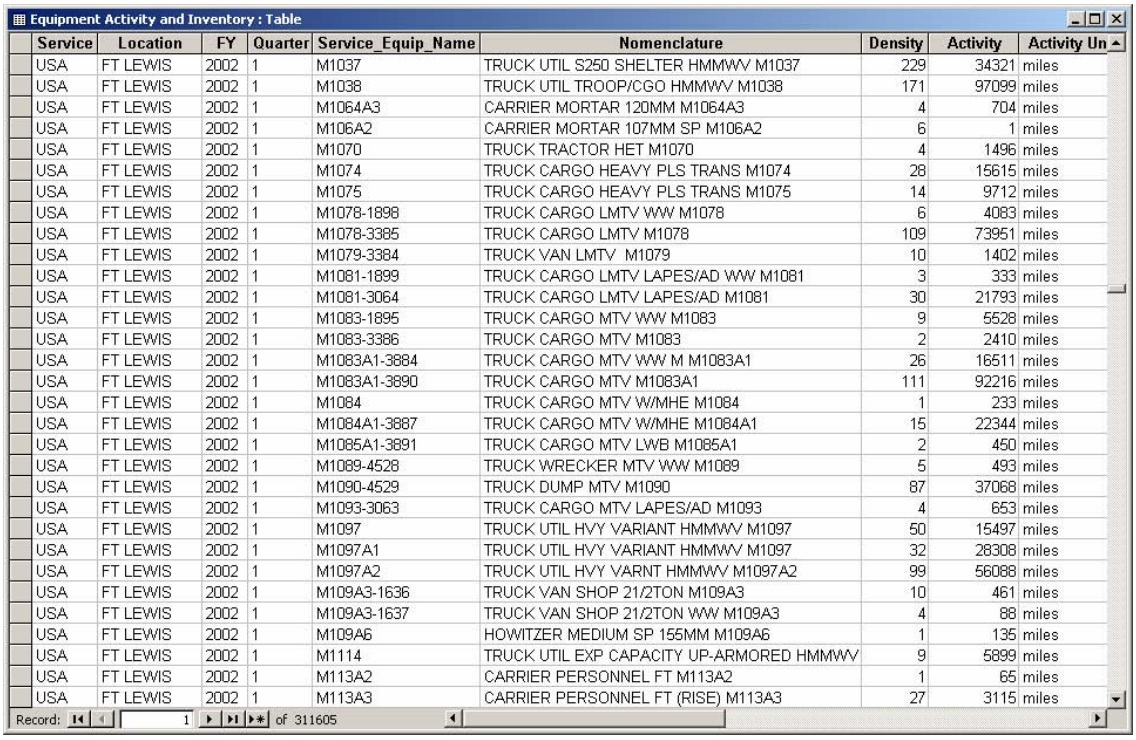


Equipment Activity and Inventory : Table

Field Name	Data Type
Location	Text
Service	Text
FY	Text
Quarter	Text
Service_Equip_Name	Text
Nomenclature	Text
Density	Number
Activity	Number
Activity Units	Text
Fuel Consumption	Number
Fuel_Name	Text
Year_Test	Text

Figure 14. Equipment Activity and Inventory table design screen.

Figure 15 contains a small sample of data from the Equipment Activity and Inventory table. The figure shows usage and inventory data for a variety of Army equipment used at Fort Lewis, WA, during the first quarter of FY2002. The records show a wide variation of density and activity. The first record contains the largest inventory value at Fort Lewis, and the second record, the largest activity level. Figure 15 shows that the Equipment Activity and Inventory table has 311,605 records. The large number of records reflects the many types of equipment used and the large number of Army Reserve and National Guard locations included in the table.



Equipment Activity and Inventory : Table

Service	Location	FY	Quarter	Service_Equip_Name	Nomenclature	Density	Activity	Activity Un
USA	FT LEWIS	2002	1	M1037	TRUCK UTIL S250 SHELTER HMMWV M1037	229	34321	miles
USA	FT LEWIS	2002	1	M1038	TRUCK UTIL TROOP/CGO HMMWV M1038	171	97099	miles
USA	FT LEWIS	2002	1	M1064A3	CARRIER MORTAR 120MM M1064A3	4	704	miles
USA	FT LEWIS	2002	1	M106A2	CARRIER MORTAR 107MM SP M106A2	6	1	miles
USA	FT LEWIS	2002	1	M1070	TRUCK TRACTOR HET M1070	4	1496	miles
USA	FT LEWIS	2002	1	M1074	TRUCK CARGO HEAVY PLS TRANS M1074	28	15615	miles
USA	FT LEWIS	2002	1	M1075	TRUCK CARGO HEAVY PLS TRANS M1075	14	9712	miles
USA	FT LEWIS	2002	1	M1078-1898	TRUCK CARGO LMTV WW M1078	6	4083	miles
USA	FT LEWIS	2002	1	M1078-3385	TRUCK CARGO LMTV M1078	109	73951	miles
USA	FT LEWIS	2002	1	M1079-3384	TRUCK VAN LMTV M1079	10	1402	miles
USA	FT LEWIS	2002	1	M1081-1899	TRUCK CARGO LMTV LAPES/AD WW M1081	3	333	miles
USA	FT LEWIS	2002	1	M1081-3064	TRUCK CARGO LMTV LAPES/AD M1081	30	21793	miles
USA	FT LEWIS	2002	1	M1083-1895	TRUCK CARGO MTV WW M1083	9	5528	miles
USA	FT LEWIS	2002	1	M1083-3386	TRUCK CARGO MTV M1083	2	2410	miles
USA	FT LEWIS	2002	1	M1083A1-3884	TRUCK CARGO MTV WW M M1083A1	26	16511	miles
USA	FT LEWIS	2002	1	M1083A1-3890	TRUCK CARGO MTV M1083A1	111	92216	miles
USA	FT LEWIS	2002	1	M1084	TRUCK CARGO MTV W/MHE M1084	1	233	miles
USA	FT LEWIS	2002	1	M1084A1-3887	TRUCK CARGO MTV W/MHE M1084A1	15	22344	miles
USA	FT LEWIS	2002	1	M1085A1-3891	TRUCK CARGO MTV LWB M1085A1	2	450	miles
USA	FT LEWIS	2002	1	M1089-4528	TRUCK WRECKER MTV WW M1089	5	493	miles
USA	FT LEWIS	2002	1	M1090-4529	TRUCK DUMP MTV M1090	87	37068	miles
USA	FT LEWIS	2002	1	M1093-3063	TRUCK CARGO MTV LAPES/AD M1093	4	653	miles
USA	FT LEWIS	2002	1	M1097	TRUCK UTIL HVY VARIANT HMMWV M1097	50	15497	miles
USA	FT LEWIS	2002	1	M1097A1	TRUCK UTIL HVY VARIANT HMMWV M1097	32	28308	miles
USA	FT LEWIS	2002	1	M1097A2	TRUCK UTIL HVY VARNT HMMWV M1097A2	99	56088	miles
USA	FT LEWIS	2002	1	M109A3-1636	TRUCK VAN SHOP 21/2TON M109A3	10	461	miles
USA	FT LEWIS	2002	1	M109A3-1637	TRUCK VAN SHOP 21/2TON WW M109A3	4	88	miles
USA	FT LEWIS	2002	1	M109A6	HOWITZER MEDIUM SP 155MM M109A6	1	135	miles
USA	FT LEWIS	2002	1	M1114	TRUCK UTIL EXP CAPACITY UP-ARMORED HMMWV	9	5899	miles
USA	FT LEWIS	2002	1	M113A2	CARRIER PERSONNEL FT M113A2	1	65	miles
USA	FT LEWIS	2002	1	M113A3	CARRIER PERSONNEL FT (RISE) M113A3	27	3115	miles

Record: 1 of 311605

Figure 15. Data from the Equipment Activity and Inventory table.

One of the most challenging aspects encountered during the population of the Equipment Activity and Inventory table was matching the MDS and MDS Name information obtained from OSMIS with a corresponding representative record from the Equipment table. This task was challenging because the MDS information was often not part of the Nomenclature information found in the Equipment table or multiple records in the Equipment table had this information. In many instances, the confusion could be resolved by using the OSMIS facility for looking up equipment by LIN and NSN, but this was a very tedious process. In other cases, references to the MDS or MDS Name had to be found from technical manuals and other Internet resources.

One outcome of resolving OSMIS equipment identification with the equipment table was the creation of three "generic" equipment names. These names were "Generic TRUCK CARGO 21/2TON M35-LD465-1", "Generic TRUCK CARGO 5TON M54-LD465-1", and "Generic TRUCK CARGO 5TON M54-LDS465-1." The generic names were created because there were a large number of MDS designations that were related to a single vehicle type. For example, the Nomenclature name "Generic TRUCK CARGO 21/2TON M35-LD465-1" corresponded to MDS designations of M109, M109A1-8365, M109A2-8308, M109A2-8313, M185, M185A2, M185A3, M275A2-1640, M275A2-1641, M756A2, and M764.

Two new names were also created in the Equipment table when none of the existing records corresponded to an MDS designation reported by OSMIS or the TAMCN description reported by the Navy VAMOSC system. For the Army, the new Nomenclature names are "SMALL UNIT SUPPORT VEHICLE (SUSV)" and "BRADLEY – LINEBACKER." For the USMC, the new Nomenclature names are "AN/TWQ-1 – Avenger," "Mobile EW Support System, AN/MLQ-36," "Radio Set, AN/MRC-145A," and "Radio Terminal Set, AN/MRC-142." In all other cases, the OSMIS and Navy VAMOSC equipment identifications were resolved with records from the Equipment table. In some instances, more than one record from the Equipment table could have been linked with an Army or USMC equipment designation, but in these cases only one of the Equipment records was selected. Some records were also created in the Equipment table that did not have any linked records in the Equipment Activity and Inventory table.

Installations Data

The Installations table was created to link a location to the Army and USMC activity and inventory information. Figure 16 shows some data from the Installation table including some major Forces Command (FORSCOM) installations where a large volume of training occurs. The table includes fields for the Service, Command, In-

stallation, City, and State. An extraction from the service and installation name information from the Equipment Activity and Inventory table initially populated this table. Unfortunately, the data from OSMIS indicated only a location name. For smaller facilities, the name usually was that of the nearest town or city. These location names were occasionally a contraction of the full name, and these contractions were not always consistent. For the first cut, the command, city, and state data were taken from the DoD FY2002 Base Structure Report (ODUSD 2002). For many of the small National Guard and Army Reserve facilities, information on city, state, and command was found through Internet resources that list government entities within cities.

The locations reported from the Navy VAMOSC system are not physical locations but organizational structures within the USMC logistics system. The following locations are reported in the USMC portion of the Navy VAMOSC system:

- I Marine Expeditionary Force (MEF)
- II MEF
- III MEF
- Depot Maintenance Float Allowance (DMFA)
- Enhanced Equipment Allowance Pool (EEAP)
- General Support
- Mobilization Allowance (MOB)
- Maritime Prepositioning Force (MPF)
- Net War Reserve Materiel Requirement (Net WRMR)
- Norway Air-Landed Marine Expeditionary Brigade
- Reserve, In Stores Assets
- Reserve Training Allowance Pool (Reserve T/A)
- Special Mission Forces.

After the Installation table was created, it contained locations that were not in the United States. These installations and the associated records in the Equipment Activity and Inventory table needed to be removed because the database was developed to look at diesel-powered off-road equipment that was regulated in the United States. Since MS Access has a cascade delete capability for linked tables, this feature was temporarily activated so that any record deleted in the Installation table would also cause the deletion of all related records in the Equipment Activity and Inventory table.

Installations : Table

Service	Command	Installation	City	State
USA	FORSCOM	FT BRAGG	Fayetteville	NC
USA	FORSCOM	FT CAMPBELL	Clarksville	TN
USA	FORSCOM	FT CARSON	Colorado Spring	CO
USA	FORSCOM	FT DRUM	Watertown	NY
USA	FORSCOM	FT GILLEM	Forest Park	GA
USA	FORSCOM	FT HOOD	Killeen	TX
USA	FORSCOM	FT IRWIN	Barstow	CA
USA	FORSCOM	FT LEWIS	Tacoma	WA
USA	FORSCOM	FT MCPHERSON	Forest Park	GA
USA	FORSCOM	FT POLK	Leesville	LA
USA	FORSCOM	FT RILEY	Junction City	KS
USA	FORSCOM	FT STEWART	Hinesville	GA
USA	FORSCOM	HARTFORD	Hartford	AL
USA	FORSCOM	HUNTER AAF	Savannah	GA
USA	FORSCOM	MIDLAND	Midland City	AL
USA	FORSCOM	NEW BROCKT	New Brockton	AL
USA	FORSCOM	OZARK	Ozark	AL
USA	FORSCOM	VANCOUVER	Vancouver	WA
USA	FORSCOM	YAKIMA FC	Yakima	WA
USA	MDW	FT AP HILL	Bowling Green	VA
USA	MDW	FT BELVOIR	Alexandria	VA
USA	MDW	FT HAMILTON	New York	NY
USA	MDW	FT MCNAIR	Washington	DC
USA	MDW	FT MEADE	Baltimore	MD
USA	MDW	FT MYER	Arlington	VA
USA	MDW	FT RITCHIE	Waynesboro	MD
USA	MEDCOM	FT DETRICK	Frederick	MD
USA	MEDCOM	FT SAM HOUSTON	San Antonio	TX
USA	MEDCOM	WALTER REED	Silver Spring	MD
USA	MTMC	SUNYPTMOT	Wilmington	NC
USA	TRADOC	CARLSLE B	Carlisle	PA
USA	TRADOC	FT BENNING	Columbus	GA

Record: 924 of 1179

Figure 16. Data from the Installation table.

Summary

This chapter describes the work done to create and populate a database that contains DoD installation, fuel, equipment, engine, and equipment activity information. Each of these data categories were placed in their own tables and relationships were set up among the tables as shown in Figure 7. Since engine, equipment, and activity information came from different sources; a large effort was undertaken to standardize equipment name and engine manufacturer and model number information across the database. The database was designed to provide a structure for developing queries and reports to analyze information across all the services. Chapter 6 describes the data analysis that was per-formed for this project using this database.

4 User Interface

The user interface was designed as a tool for users to browse through data and display or print reports that summarize the information in useful ways. The user interface is actually a separate MS Access database containing the forms, queries, reports, and associated Visual Basic for Applications code that constitute the interface. The interface requires the user to have MS Access 2000 or above. The user begins by opening: "DoD_Diesel_Off_Road_Activity_Interface.mde." An MS Access file with the mde extension contains working versions of the database objects but does not allow users to modify or delete any of the database objects. When the interface file is opened, the user is prompted to select a data set file as shown in Figure 17.

The highlighted file (Figure 17) is "Original_DoD_Diesel_Off_Road_Data.org" and contains the original data included in the database described in Chapter 3. For ease of use, this file should be in the same Windows folder as the user interface database. The file is password protected and encrypted to prevent changes to the information. However, users are allowed to create their own versions of this database. The files "Test1.scn" and "Test2.scn" are examples of user-created datasets.

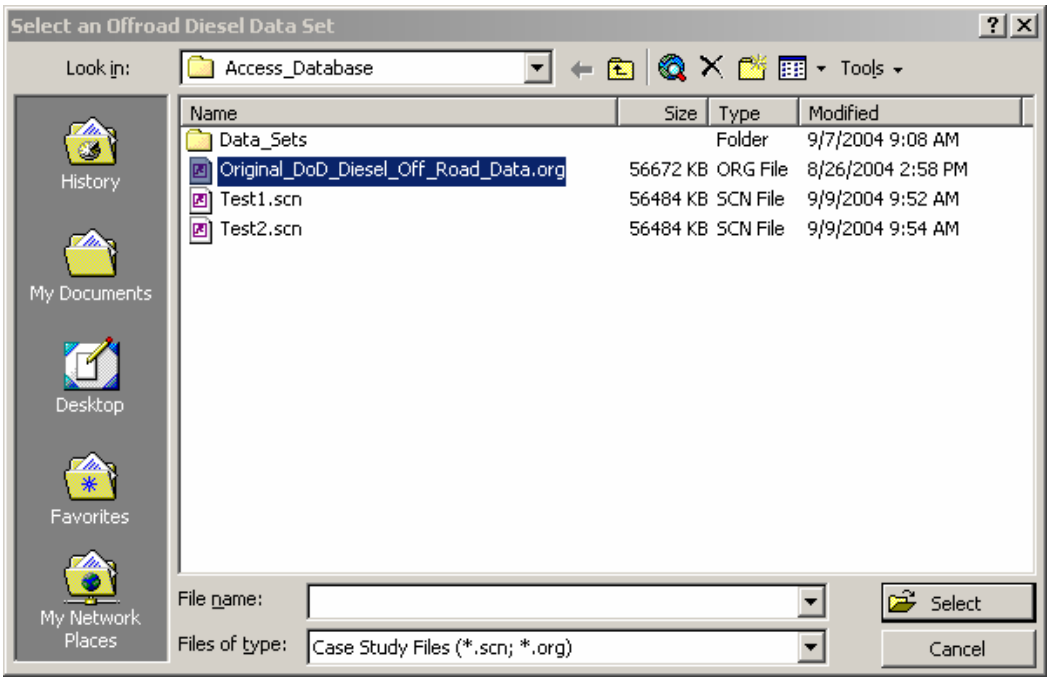


Figure 17. Data set selection screen.

After a user selects a file, the file selection screen disappears, the hourglass cursor appears, and the message "Creating temporary database. Please wait…" is displayed on the bottom of the screen. At this point, the user interface application is creating a temporary database that is an exact copy of the selected file. The user interface interacts with the temporary database and users are able to save changes upon exiting the interface or selecting another file. The use of a temporary database allows users to make live changes to the database while maintaining a copy of the original information if the user wants to maintain that dataset. Because of the large amount of information, the creation of the temporary database may take several minutes. The amount of time required will improve with faster processors or more system memory.

Opening Screen

After the temporary database is created, the opening screen of the user interface appears as shown in Figure 18. This screen contains push button controls for viewing and modifying data, report generation, saving and loading case study files, and exiting the user interface. The top of the opening screen displays the name of the case study database file name.

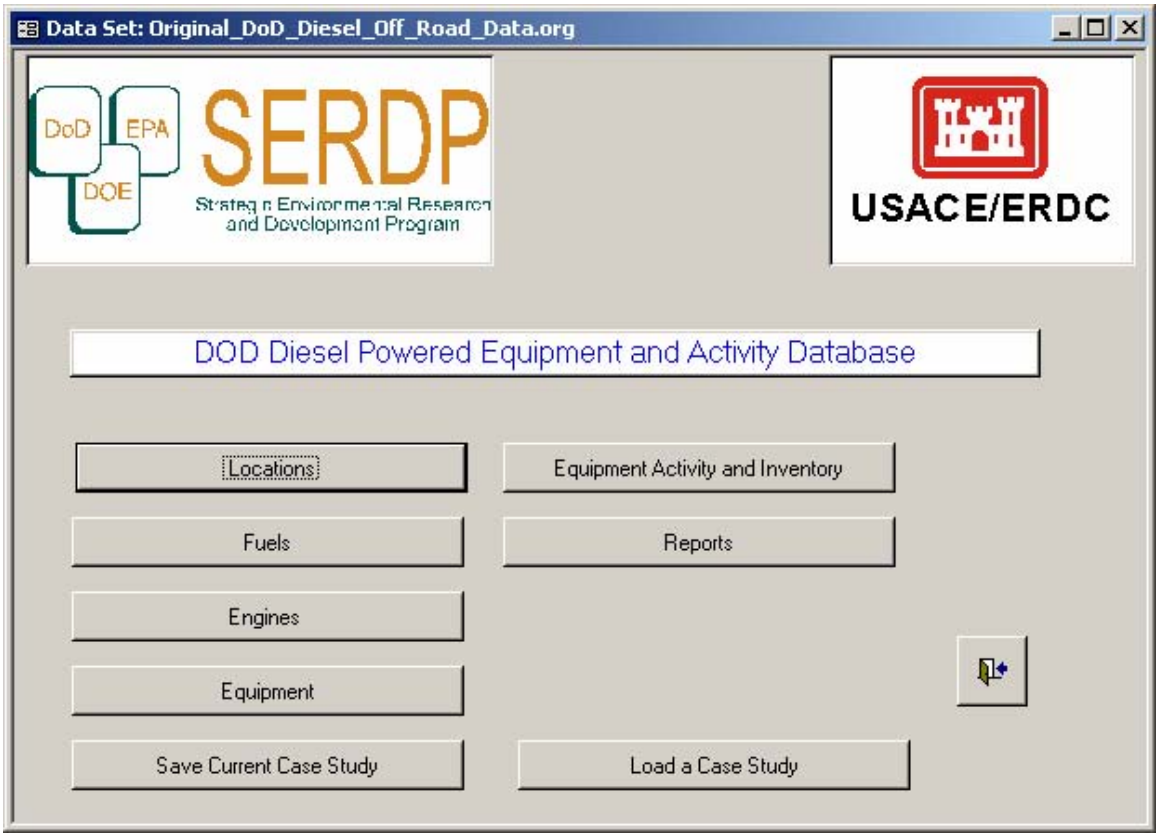


Figure 18. Opening screen of the user interface.

If a user elects to save a file, a screen similar to Figure 17 is displayed except that the file "Original_DoD_Diesel_Off_Road_Data.org" is not shown so that users will not try to overwrite the original data file. However, users do have the option to overwrite an existing case study file or save the information in a new file name. The saving operation could take several minutes, and the top of the opening screen will show the name of the saved file. If a user chooses to load a new file, again a screen similar to Figure 17 is displayed and the original dataset file is displayed since users may want to load this file. However, if a user has modified information before choosing to load a new file, the interface will first provide the option of saving the modified file.

Forms for Data Display and Editing

The buttons for Locations, Fuels, Engines, Equipment, and Equipment Activity and Inventory open up forms that allow display and modification of data found in the tables with names the same as the buttons. For example, Figure 19 shows the Engines form that is displayed after selecting the Engines button. All the forms will display the form name on the top of the form and display information from more than one record at a time. On the top right of each form will be standard buttons for minimizing, maximizing/restoring, and closing the form. The bottom of each form will include record navigation and new record entry buttons.

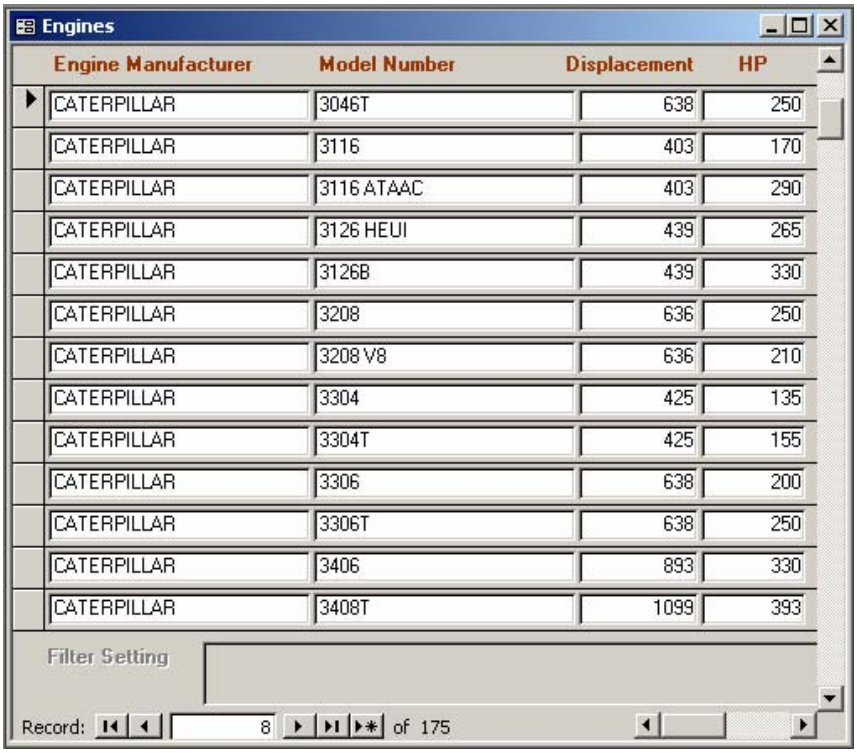


Figure 19. Engines form.

The Enter or Tab key will move from field to field and the Page Up and Page Down key will move to the next and previous records respectively. The Delete key will either delete information found in a field or attempt to delete the entire record if the entire record has been previously selected by clicking on the bar to the left of a record. The interface will ask for confirmation before deleting a record. Changes are not actually stored in the linked table until the user moves to another record.

The custom toolbar shown in Figure 20 is also displayed at the top of each form. This toolbar gives users access to some useful functions built in to MS Access. Table 9 briefly describes the actions that each of these buttons will perform. As was discussed in the previous paragraph, some of these actions can also be performed using the keyboard or buttons included on the form.

Figure 20. Custom toolbar displayed on the top of forms.

Table 9. Actions performed by each of the buttons in the custom toolbar.

Icon	Action	Icon	Action
	Switch to the form view		Go to the first record
	Switch to the datasheet view		Go to the previous record
	Search and replace text		Go to the next record
	Find the next occurrence of text		Go to the last record
	Order the records in ascending order by the current field(s)		Enter a new record
	Order the records in descending order by the current field(s)		Delete the current record
	Filter records using the highlighted data		Cut the highlighted data into the clipboard
	Filter records by entering conditions on the form		Copy the highlighted data into the clipboard
	Toggle the current filter on or off		Paste the clipboard data at the cursor point
	Open the advanced filter/sort screen		Undo the previous change
			Exit the form

The  and  buttons cause the form view and datasheet view to be displayed, respectively. Figure 19 shows the Engines form view and Figure 21 shows the datasheet view of the same form. The datasheet view is similar to a spreadsheet table with the field names as the column headings. In the datasheet view, users can modify the width of columns and change the relative position of columns. Several columns can be selected and be used together to change the display order with the leftmost column being used as the primary sort key followed in order by selected columns to the right.

Engines

Engine_Manufacturer	Model_Number	Displacement	HP
CATERPILLAR	3046T	638	250
CATERPILLAR	3116	403	170
CATERPILLAR	3116 ATAAC	403	290
CATERPILLAR	3126 HEUI	439	265
CATERPILLAR	3126B	439	330
CATERPILLAR	3208	636	250
CATERPILLAR	3208 V8	636	210
CATERPILLAR	3304	425	135
CATERPILLAR	3304T	425	155
CATERPILLAR	3306	638	200
CATERPILLAR	3306T	638	250
CATERPILLAR	3406	893	330
CATERPILLAR	3408T	1099	393
CATERPILLAR	342	1286	486
CATERPILLAR	343T/A	893	334
CATERPILLAR	7BJ TYPE II	243	85
CATERPILLAR	9RM TYPE I	243	85
CATERPILLAR	C-12	830	425

Record: 26 of 175

Figure 21. Datasheet view of the Engines table.

The  button is used to search for text or to search and replace text. Pressing this button opens up the MS Access Find and Replace form as shown in Figure 22. This single form can be used for both finding and replacing data and the form offers several options for improving the search through the table. The  button will repeat the most recently performed search.

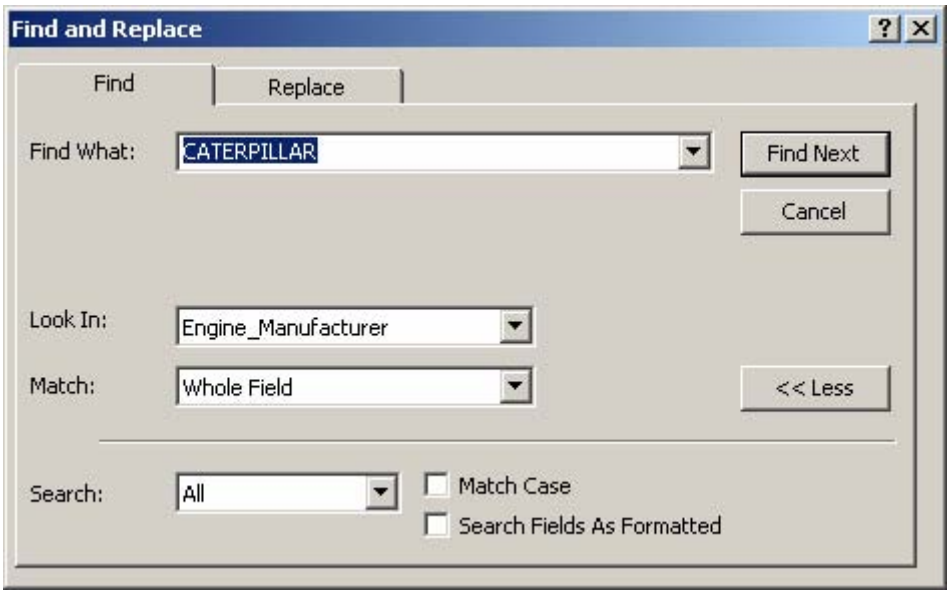


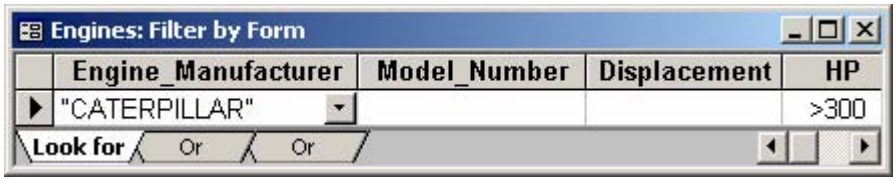
Figure 22. MS Access Find and Replace form.

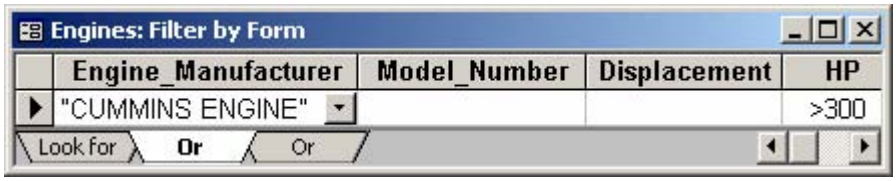
The  and  buttons will sort the records in the current view in ascending and descending order respectively. In the form view, the order will be based on the field where the cursor is located when one of the buttons are pushed. In the datasheet view, several columns can be used to affect the sort order. After a sort operation is performed, the record pointer will move to the first record in the new view.

A number of MS Access features allow users to filter the display of data in the form and datasheet views. A filter allows users to view a subset of the data based on conditions placed on the view. The  "filter by selection" button places a simple condition on the current view that is based on the field where the cursor is located when the button is selected. The filter will be X = Z where X is the name of the field and Z is the value of the field where the cursor is located. For example, if the Engines form is displayed and the cursor is in the Engine_Manufacturer field and the value for the current record is "CATERPILLAR" then the filter becomes Engine_Manufacturer = "CATERPILLAR" and only records where the engine manufacturer is Caterpillar are displayed. The  button also toggles the  "apply filter button" so that the results of the filter are viewed immediately. If users

continue to press the  button in different fields, the original condition will be expanded by adding new "AND" conditions based on each of the new fields and their values. A new condition will be started if a user untoggles the  button and selects the  button again.

The  button activates the "filter by form" feature that allows users to enter filter conditions in a form or datasheet view. The conditions can be the value of a field or users can enter more complex conditions. Figure 23 shows an example of conditions entered in the "Look for" and "Or" tabs of the Engines filter-by form screens and the results of these conditions shown in the Engines form view window. In this example, engines manufactured by both Caterpillar and Continental are displayed on the form. The form view shown in Figure 23 also illustrates the "Filter Setting" text box that will display the current filter settings. This text box is included on the bottom of all forms that display data from database tables. The forms will also display the text "(Filtered)" to the right of the record navigation buttons on the bottom of the form. Printed or online MS Access help can advise users further on ways of filtering data using the filter-by form feature.





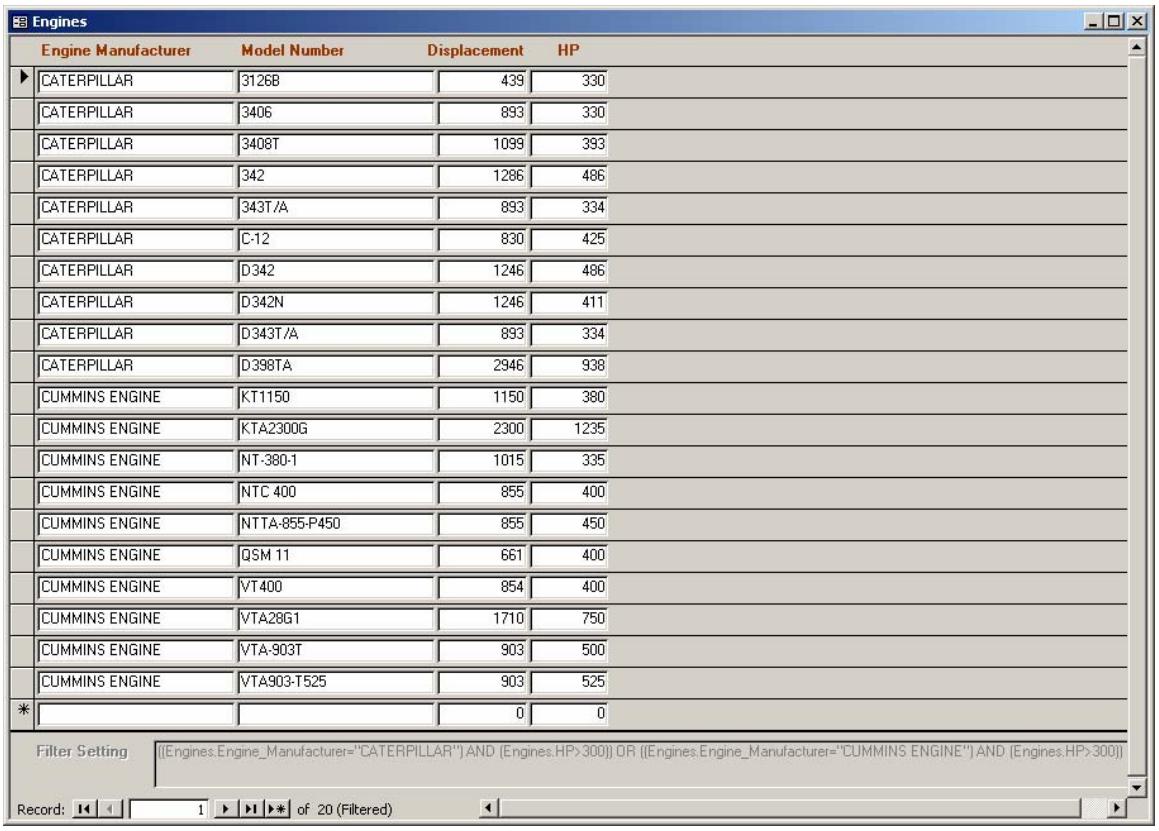


Figure 23. Filter by form conditions and results for the Engines table.

The  button opens the advanced filter/sort screen. This screen is the MS Access query design screen that allows users to enter very complicated filter and sort conditions. Additional information about using query design screens can be found in an MS Access user manual or from online help.

The  ,  ,  , and  buttons are used for navigating the records on a form and are used to go to the last record, the next record, the previous record, and the first record, respectively. The navigation buttons will apply to the currently active sort and filter. The  button is used to enter a new record. Selecting this button will move the record pointer to a blank record on the screen where the user fills in the appropriate information. This can also be accomplished using the same record navigation button on the bottom of the form or manually using the keyboard or mouse. The  button will attempt to delete the current record or multiple records if more than one is selected. Users will be asked for confirmation before deleting records since the deletion operation is permanent.

The  ,  , and  buttons perform the MS Windows cut, copy, and paste operations, respectively. These operations should be familiar to everyone who has worked with other MS Windows applications. The  button performs an undo operation on the most recent database change. There is only one level of undo, and record deletions cannot be undone. The  button exits the form and returns to the opening screen of the user interface.

The remaining forms for displaying and editing data from the tables work the same way as the Engines form and use the same custom toolbar. Figure 24 shows the Installations form, Figure 25 shows the Fuels form, Figure 26 shows the Equipment form, and Figure 27 shows the Equipment Activity and Inventory form.

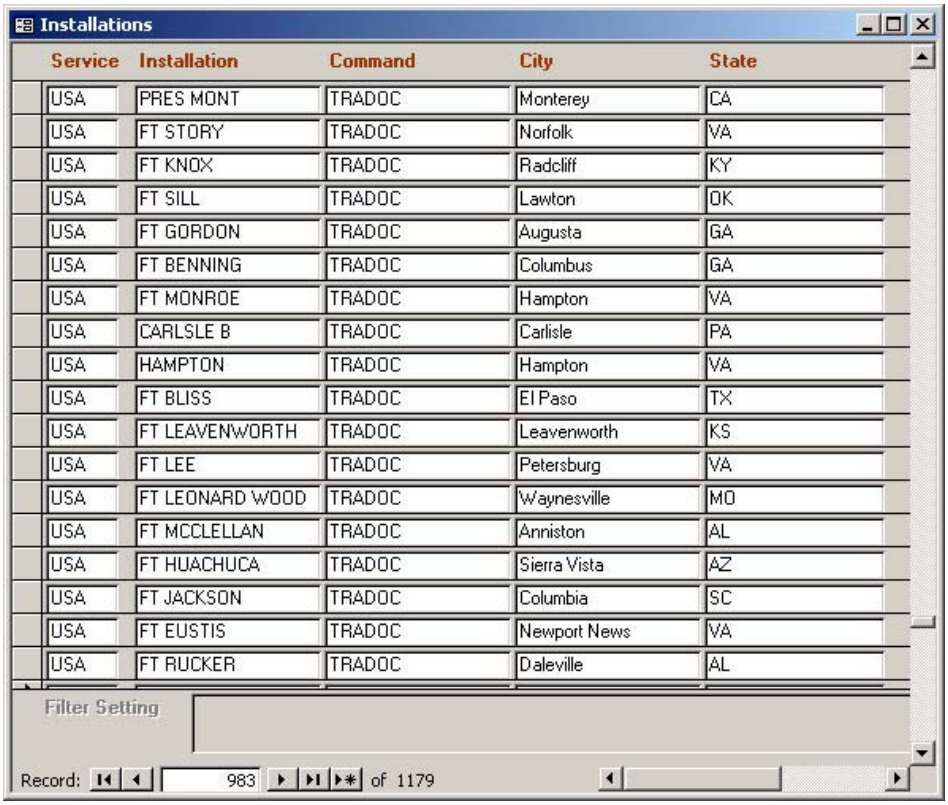


Figure 24. Installation form.

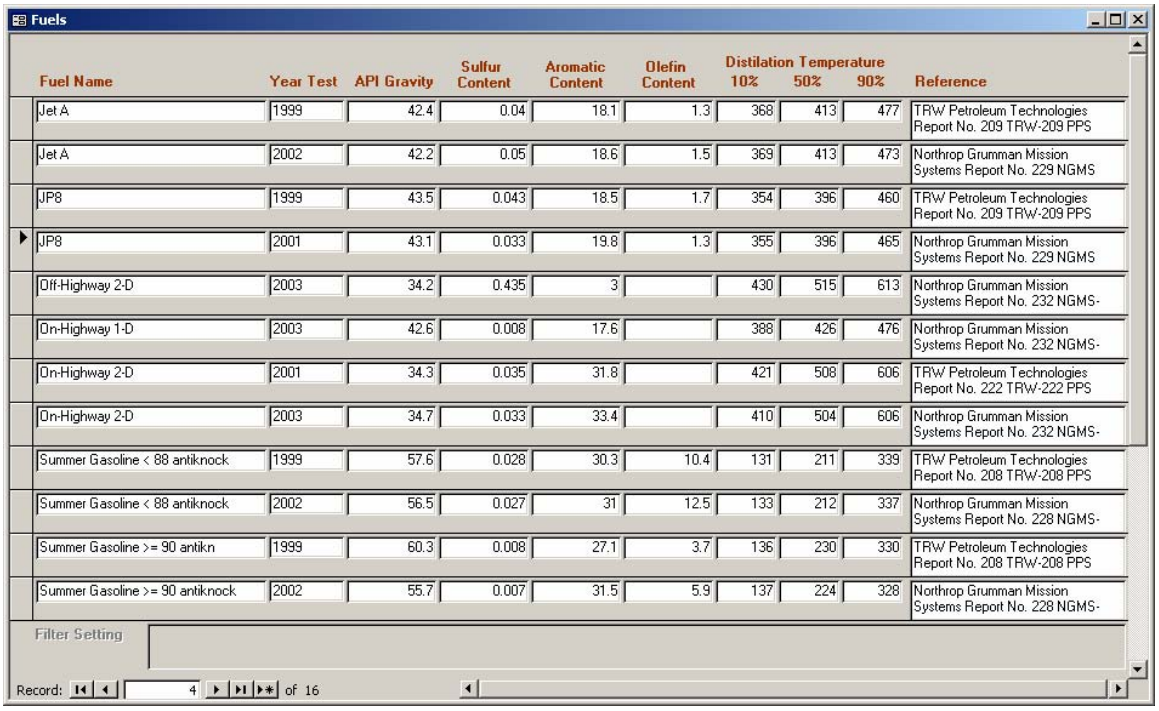


Figure 25. Fuels form.

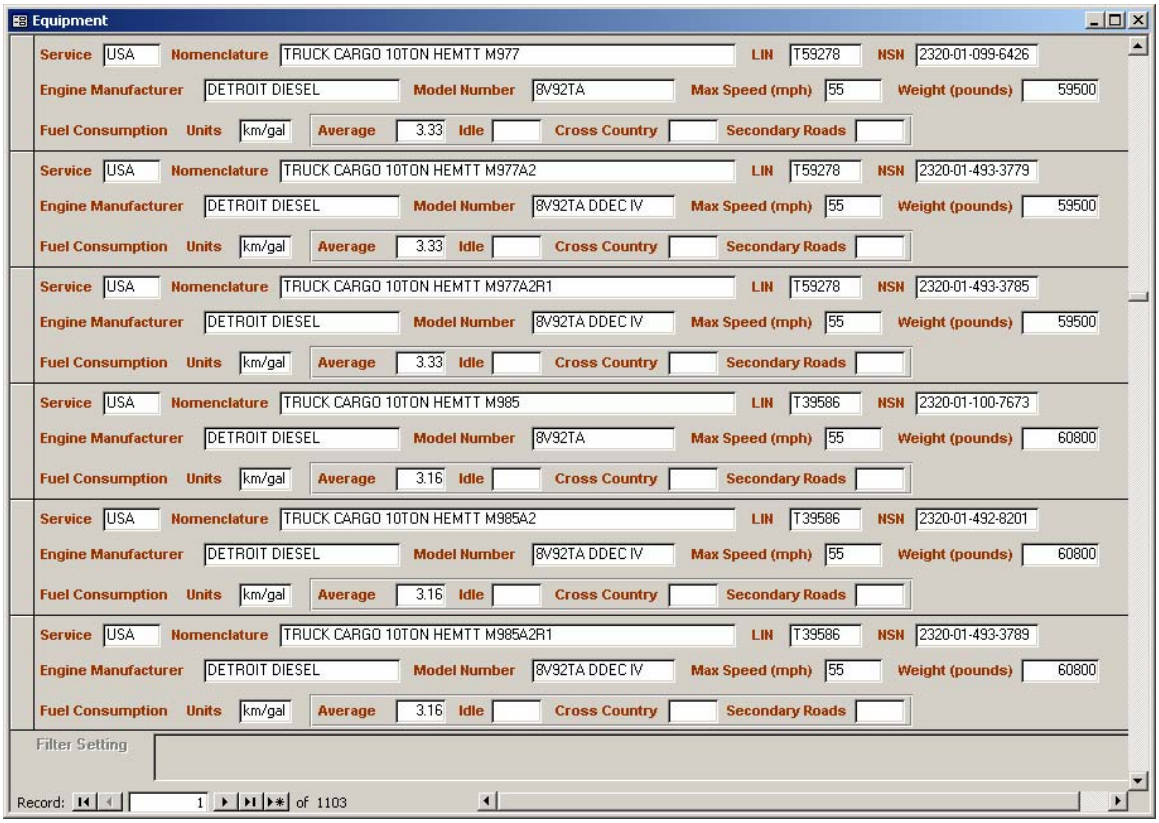


Figure 26. Equipment form.

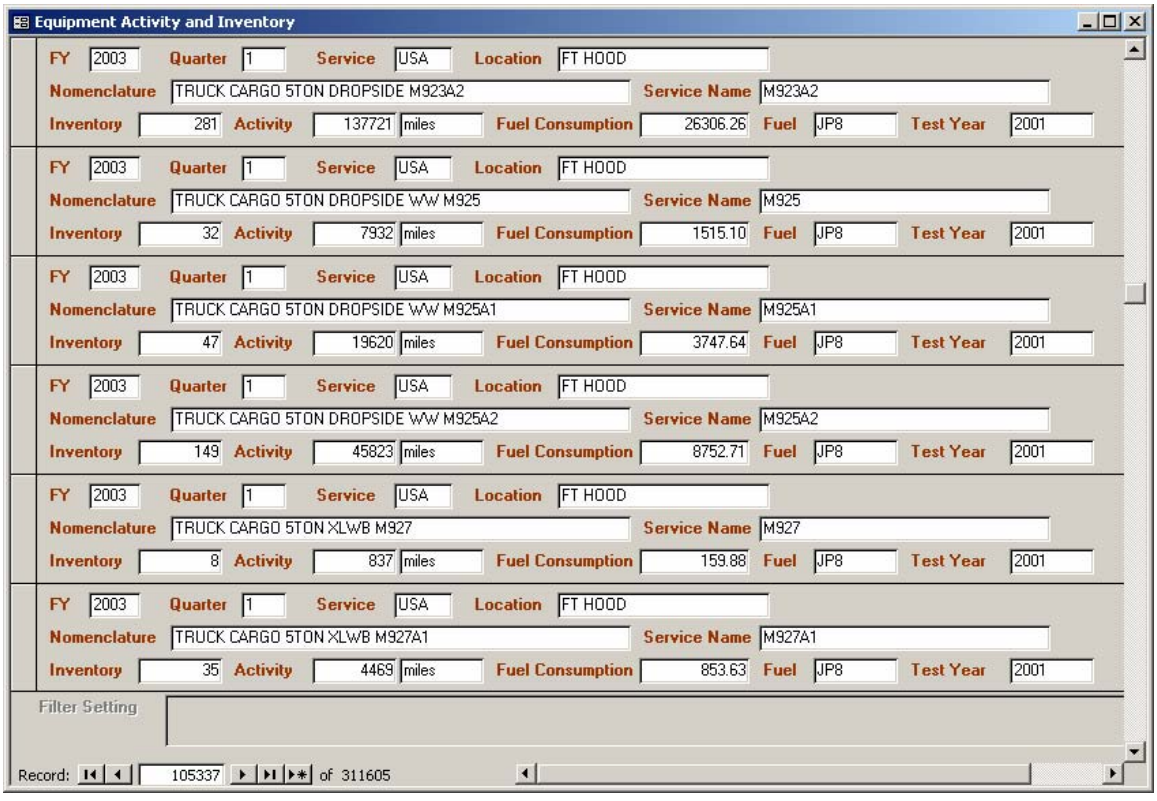


Figure 27. Equipment Activity and Inventory form.

Reports Generation

The opening screen of the user interface also has a button for opening a report generation form. When the Reports button is selected, there will be a delay as the system fills in temporary tables that allow the selection of criteria for some of the reports. The Reports form first requires the selection of a report from a pick list and then presents users several options for setting conditions on the reports. The conditions will vary depending on the report that is selected and the conditions will default to the most inclusive. Figure 28 shows the Reports form after a user has selected the Engine Fuel Consumption report and has also elected to create a report showing only Army information from FY2003. Some condition selection lists will appear only after another related selection is made. For example, in Figure 28 the Installation selection list only appears after an individual service is selected. Users generate report previews by selecting the Preview button. Users can also send reports directly to a printer by selecting the Print button. When users select the Print or Preview button, report generation will cause a delay before the report results are printed or displayed.

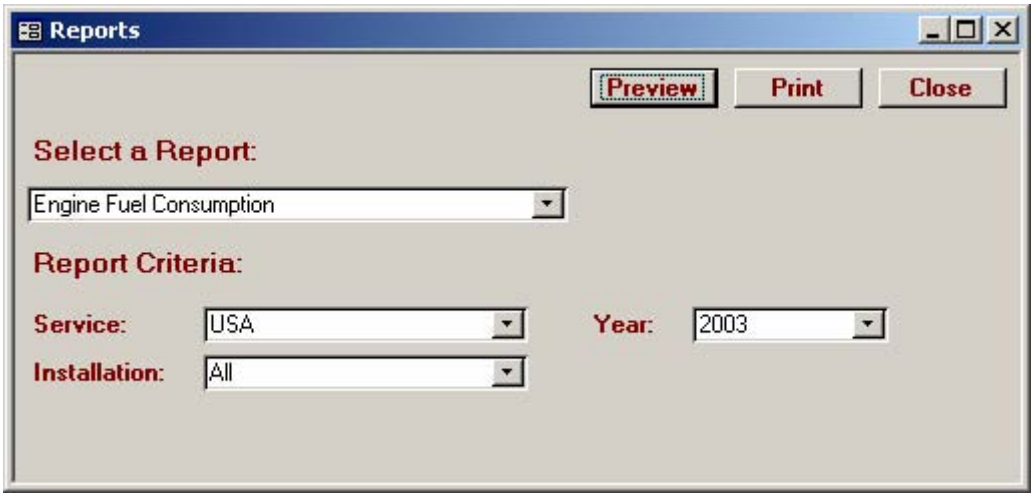


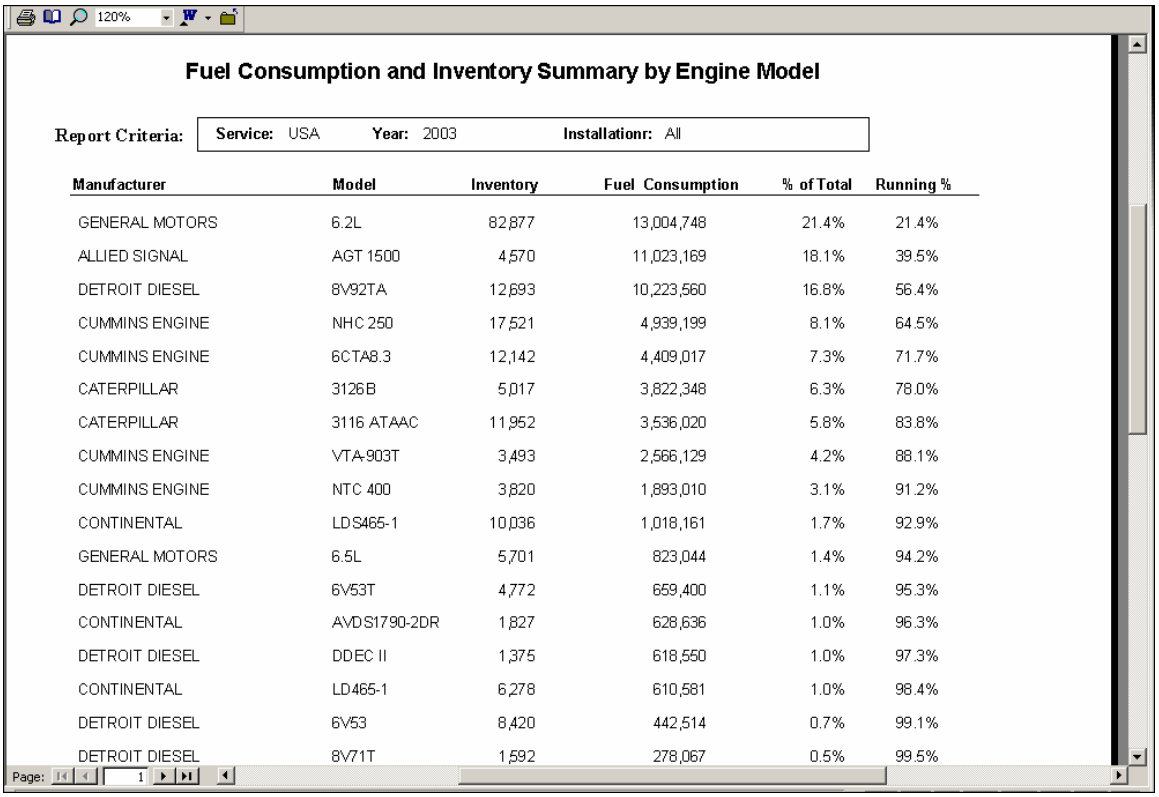
Figure 28. Report selection and criteria form.

The Reports form allows users to select from the following fuel consumption and inventory reports:

- Engine Fuel Consumption
- Engine Fuel Consumption with Equipment List
- Equipment Fuel Consumption
- Equipment Fuel Consumption with Installation List
- Installation Fuel Consumption
- Installation Fuel Consumption with Equipment List.

Each report summarizes fuel consumption as indicated by the name of the report. For example, the Engine Fuel Consumption report shows total fuel consumption by engine models. The Engine Fuel Consumption with Equipment List also summarizes engine fuel consumption, but also lists fuel consumption of equipment that uses a particular engine type.

Figure 29 shows the report preview screen for the report and criteria conditions shown in Figure 28. As in all the reports, the report criteria are shown at the top of the page. The report preview is an MS Access feature that allows the user to view the report on the screen, set the zoom level of the report on the screen, create an MS Word document containing the report, modify the page setup for the report, and send the report to a printer.



Fuel Consumption and Inventory Summary by Engine Model

Report Criteria: Service: USA Year: 2003 Installationr: All

Manufacturer	Model	Inventory	Fuel Consumption	% of Total	Running %
GENERAL MOTORS	6.2L	82,877	13,004,748	21.4%	21.4%
ALLIED SIGNAL	AGT 1500	4,570	11,023,169	18.1%	39.5%
DETROIT DIESEL	8V92TA	12,693	10,223,560	16.8%	56.4%
CUMMINS ENGINE	NHC 250	17,521	4,939,199	8.1%	64.5%
CUMMINS ENGINE	6CTA8.3	12,142	4,409,017	7.3%	71.7%
CATERPILLAR	3126B	5,017	3,822,348	6.3%	78.0%
CATERPILLAR	3116 ATAAC	11,952	3,536,020	5.8%	83.8%
CUMMINS ENGINE	VTA-903T	3,493	2,566,129	4.2%	88.1%
CUMMINS ENGINE	NTC 400	3,820	1,893,010	3.1%	91.2%
CONTINENTAL	LDS465-1	10,036	1,018,161	1.7%	92.9%
GENERAL MOTORS	6.5L	5,701	823,044	1.4%	94.2%
DETROIT DIESEL	6V53T	4,772	659,400	1.1%	95.3%
CONTINENTAL	AVDS1790-2DR	1,827	628,636	1.0%	96.3%
DETROIT DIESEL	DDEC II	1,375	618,550	1.0%	97.3%
CONTINENTAL	LD465-1	6,278	610,581	1.0%	98.4%
DETROIT DIESEL	6V53	8,420	442,514	0.7%	99.1%
DETROIT DIESEL	8V71T	1,592	278,067	0.5%	99.5%

Figure 29. Report preview screen of the Engine Fuel Consumption report for 2003 Army data.

Summary

This chapter described the user interface that was designed as a tool for users to browse through data and display or print reports that summarize the information in useful ways. The user interface is an MS Access database that links to the information database described in Chapter 3 and the interface uses many of MS Access's built in controls. The interface allows users to connect to the original data or to

modify this data and create new data sets. There are separate forms for viewing installation, fuel, engine, equipment, and equipment activity and inventory data. The forms allow user-specified views by filtering the data using options found in a tool bar. The interface also contains a report generation feature that allows users to select from several built-in reports and set criteria for the report that filter the results. The interface allows users without detailed knowledge of the MS Access database system a way to easily and safely interact with the large amount of provided data.

5 Data Analysis

This chapter describes two types of data analyses that were performed using the developed database and user interface. The objective of the first analysis was to provide activity information that would show the types of diesel-powered off-road equipment used most frequently. The usage patterns provide information that is useful in determining the priority for engine emission testing. The objective of the second data analysis was to compare fuel usage reported by OSMIS with fuel usage information found in the Headquarters Redesigned Army Defense Utilities Energy Reporting System (DUERS) Data System (HQRADDS). This type of comparison could help to validate the OSMIS fuel usage information that is calculated from expected fuel usage rates and either vehicle miles driven or hours of operation.

Army and USMC Emission Testing Priority

One of the primary purposes of developing the DoD diesel-powered off-road equipment activity database was to help prioritize this equipment by the potential to generate engine emissions. The database report that is most useful for this purpose is the Engine Fuel Consumption report that totals fuel usage for each engine and presents the results in descending order of the totals. This report will tend to group similar types of equipment together since each diesel engine model will most often be used in different pieces of equipment that share a similar function. The data displayed in all the tables in this section were extracted from much more detailed reports. The Appendix contains the complete report results ob-tained when generating the Engine Fuel Consumption report and the Engine Fuel Consumption with Equipment List report for all services and for FY2003. These results were used to create Table 11.

Table 10 shows results from this report for both the Army and the USMC for FY2001–2003. Table 10 includes a column displaying typical equipment that uses each engine type. The data indicates that the top five ranked engines account for more than 50 percent of the fuel usage, the top ten almost 78 percent, and the top 20 almost 92 percent. High mobility multi-purpose wheeled vehicles (HMMWVs); tanks (M1A1, M1A2); trucks (HEMTT, 5-ton, family of medium tactical vehicles [FMTV], 10-ton); the amphibious assault vehicle (AAV); the logistics vehicle system (LVS); and the Bradley fighting vehicle (M2A2, M3A2) use almost 80 percent of the fuel. Three generator sets and a forklift are included in Table 10, but the reported

fuel usage is only from the USMC. This is because of the OSMIS problem (discussed in Chapter 2) of not reporting activity correctly for equipment that has usage measured in hours. If OSMIS did report activity for nonvehicular equipment correctly, then this type of equipment would certainly be more prominent in Table 10.

Table 10. Top 20 Army and USMC off-road diesel engine fuel consumptions for FY2001–2003.

Rank	Manufacturer	Model	Representative Equipment	Average Inventory	Fuel Usage (gallons)	Percent of Total	Running Total (%)
1	GENERAL MOTORS	6.2L	HMMWV	99,398	44,906,900	17.5	17.5
2	ALLIED SIGNAL	AGT 1500	M1A1, M1A2	4,673	40,630,794	15.8	33.3
3	DETROIT DIESEL	8V92TA	HEMTT	13,694	29,108,653	11.3	44.6
4	CUMMINS ENGINE	NHC 250	5-ton truck	25,985	20,375,687	7.9	52.5
5	DETROIT DIESEL	6V53T	LAV, APC	5,395	18,513,284	7.2	59.7
6	CUMMINS ENGINE	6CTA8.3	5-ton truck	13,866	12,007,328	4.7	64.4
7	CATERPILLAR	3116 ATAAC	FMTV	12,944	10,041,649	3.9	68.3
8	CUMMINS ENGINE	VT400	AAV	1,147	9,449,304	3.7	72.0
9	DETROIT DIESEL	8V-92	MK48 LVS	1,308	8,379,559	3.3	75.2
10	CUMMINS ENGINE	NTC 400	10-ton truck tractor	4,103	6,020,515	2.3	77.6
11	CUMMINS ENGINE	VTA-903T	M2A2, M3A2	3,528	5,628,003	2.2	79.8
12	JOHN DEERE	6466 6.8L	Tractor, Loader	513	5,501,174	2.1	81.9
13	CATERPILLAR	3126B	Stryker, FMTV	3,018	4,840,063	1.9	83.8
14	ALLIS CHALMERS	3500	60-kW generator	1,023	4,504,264	1.8	85.6
15	CONTINENTAL	LDS465-1	M35A2, 2.5-ton truck	11,227	3,851,595	1.5	87.1
16	CONTINENTAL	AVDS1790-2DR	M88A1 recovery vehicle	1,799	3,196,994	1.2	88.3
17	HERCULES ENGINE	D298ERX37	30-kW generator	1,089	2,928,512	1.1	89.4
18	CONTINENTAL	LD465-1	M35A2 2.5-ton truck	7,798	2,388,461	0.9	90.4
19	ONAN DIV	DN4M1	10-kW generator	2,977	2,209,545	0.9	91.2
20	JOHN DEERE	6059T	Truck forklift	2,291	2,093,352	0.8	92.0

Since the activity information in the database includes FY2001–2003, the data might reflect changes in equipment usage that occurred within DoD over that time period. To illustrate that change, the Engine Fuel Consumption report was run for both the Army and USMC but only for FY2003. Table 11 shows these results. The order of the top six engines remained the same in Table 11 as it was in Table 10, and the total fuel consumption for these six engines accounted for almost the same percentage of consumption. The engine that showed the largest increase in fuel consumption was the Caterpillar 3126B. This increase is due to the increased deployment and usage of the Stryker vehicle between FY2001 and FY2003. Engines employed in generator sets also showed increases over this time period as the

engines powering 10-kW, 30-kW, and 60-kW generator sets all had larger inventories and fuel consumptions. Engines showing marked decreases included the Cummins Engine VT 400, which powers the USMC AAV, the Cummins Engine NTC 400, which powers Army 10 ton trucks, and the John Deere 6466 6.8L, which powers a USMC tractor/loader.

Table 11. Top 20 Army and USMC off-road diesel engine fuel consumptions for FY2003.

Rank	Manufacturer	Model	Representative Equipment	Average Inventory	Fuel Usage	Percent of Total	Running Total (%)
1	GENERAL MOTORS	6.2L	HMMWV	94,928	14,743,248	17.3	17.3
2	ALLIED SIGNAL	AGT 1500	M1A1, M1A2	4,973	14,129,437	16.5	33.8
3	DETROIT DIESEL	8V92TA	HEMTT	12,693	10,223,560	12.0	45.8
4	CUMMINS ENGINE	NHC 250	5-ton truck	23,525	7,112,306	8.3	54.1
5	DETROIT DIESEL	6V53T	LAV, APC	5,451	4,812,455	5.6	59.7
6	CUMMINS ENGINE	6CTA8.3	5-ton truck	12,142	4,409,017	5.2	64.9
7	CATERPILLAR	3126B	Stryker, FMTV	5,017	3,822,348	4.5	69.3
8	CATERPILLAR	3116 ATAAC	FMTV	11,952	3,536,020	4.1	73.5
9	CUMMINS ENGINE	VTA-903T	M2A2, M3A2	3,493	2,566,129	3.0	76.5
10	ALLIS CHALMERS	3500	60-kW generator	1,215	2,554,053	3.0	79.5
11	DETROIT DIESEL	8V-92	MK48 LVS	1,298	2,175,720	2.5	82.0
12	CUMMINS ENGINE	VT400	AAV	1,161	2,167,047	2.5	84.6
13	CUMMINS ENGINE	NTC 400	10-ton tractor	3,820	1,893,010	2.2	86.8
14	HERCULES ENGINE	D298ERX37	30-kW generator	1,439	1,127,779	1.3	88.1
15	CONTINENTAL	LDS465-1	M35A2, 2.5 ton truck	10,036	1,018,161	1.2	89.3
16	ONAN DIV	DN4M1	10-kW generator	3,864	1,004,081	1.2	90.5
17	CONTINENTAL	AVDS1790-2DR	M88A1 recovery vehicle	1,889	899,277	1.1	91.5
18	GENERAL MOTORS	6.5L	Heavy HMMWV	5,701	823,044	1.0	92.5
19	JOHN DEERE	6059T	Truck forklift	2,453	660,040	0.8	93.2
20	DETROIT DIESEL	DDEC II	20-ton truck	1,375	618,550	0.7	94.0

The Engine Fuel Consumption report can also illustrate differences and similarities between the diesel engine activity in the Army and USMC. Table 12 shows the top ten engines ranked by their fuel consumptions in FY2003 for the Army and Table 13 shows the same information for the USMC. A similarity between the services is that the top ten engines account for a large percentage of the overall fuel usage with overall percentages of 92.9 and 84.5 for the Army and USMC, respectively. The M1 tank, powered by the Allied Signal AGT 1500 turbine engine, accounts for the second highest percentage of fuel usage for both services. One difference between the services is the larger amount of overall fuel usage by the Army. Table 12 reports

individual fuel usages that correspond to a total fuel usage of about 61 million gallons for the Army; while, the individual fuel usages shown in Table 13 corresponds to a total fuel usage of 25 million gallons for the USMC. The tables also indicate a larger reliance on trucks for the Army with their engines accounting for 42.8 percent of overall fuel consumption in Table 12. Table 13 also lists three generator sets in the top ten, and the Army fuel usage list may have shown similar activity if the fuel usage information for this type of equipment was reported correctly in OSMIS.

Table 12. Top 10 Army off-road diesel engine fuel consumptions for FY2003.

Rank	Manufacturer	Model	Representative Equipment	Average Inventory	Fuel Usage (gallons)	Percent of Total	Running Total (%)
1	GENERAL MOTORS	6.2L	HMMWV	82,877	13,004,748	21.4	21.4
2	ALLIED SIGNAL	AGT 1500	M1A1, M1A2	4,570	11,023,169	18.1	39.5
3	DETROIT DIESEL	8V92TA	HEMTT	12,693	10,223,560	16.8	56.4
4	CUMMINS ENGINE	NHC 250	5-ton truck	17,521	4,939,199	8.1	64.5
5	CUMMINS ENGINE	6CTA8.3	5-ton truck	12,142	4,409,017	7.3	71.7
6	CATERPILLAR	3126B	Stryker, FMTV	5,017	3,822,348	6.3	78.0
7	CATERPILLAR	3116 ATAAC	FMTV	11,952	3,536,020	5.8	83.8
8	CUMMINS ENGINE	VTA-903T	M2A2, M3A2	3,493	2,566,129	4.2	88.1
9	CUMMINS ENGINE	NTC 400	10-ton tractor	3,820	1,893,010	3.1	91.2
10	CONTINENTAL	LDS465-1	M35A2, 2.5-ton truck	10,036	1,018,161	1.7	92.9

Table 13. Top 10 USMC off-road diesel engine fuel consumptions for FY2003.

Rank	Manufacturer	Model	Representative Equipment	Average Inventory	Fuel Usage (gallons)	Percent of Total	Running Total (%)
1	DETROIT DIESEL	6V53T	LAV	679	4,153,055	16.8	16.8
2	ALLIED SIGNAL	AGT 1500	M1A1, M1A2	403	3,106,268	12.6	29.4
3	ALLIS CHALMERS	3500	60-kW generator	609	2,553,774	10.4	39.8
4	DETROIT DIESEL	8V-92	5-ton truck, MK48 LVS	1,298	2,175,720	8.8	48.6
5	CUMMINS ENGINE	NHC 250	5-ton truck, M923A1	6,004	2,173,107	8.8	57.4
6	CUMMINS ENGINE	VT400	AAV	1,161	2,167,047	8.8	66.2
7	GENERAL MOTORS	6.2L	HMMWV	12,051	1,738,500	7.0	73.2
8	HERCULES ENGINE	D298ERX37	30-kW generator	1,010	1,127,608	4.6	77.8
9	ONAN DIV	DN4M1	10-kW Generator	1,343	1,004,037	4.1	81.9
10	JOHN DEERE	6059T	Truck forklift, 60-kW generator	613	659,871	2.7	84.5

Fuel Consumption Comparison with HQRADDS

HQRADDS is a database of fossil fuel use within the Army. DUERS applies only to the Army-wide database maintained at the Assistant Chief of Staff Installation Management System (ACSIM) and is accessed by authorized users of the Army energy program. Authorized users can access HQRADDS at: https://hqradds.hqda.pentagon.mil/index1.html.

At one of this project's review presentations, it was suggested that a comparison be made between the fuel usage information generated from OSMIS and the information contained in HQRADDS. It was believed that this type of comparison would provide a validation of OSMIS fuel consumption data which, as was mentioned in Chapter 2, are not reported directly to OSMIS but are calculated from activity information and the expected fuel consumption rate.

Unfortunately, the comparison between the two systems is not exact or straightforward. One difference is that HQRADDS reports fuel usage based on what installations purchase and use at their locations while OSMIS fuel usage is based on an installation's activity information, regardless of where it is used. Another difference is that the mobility fuel usage reported in HQRADDS includes aviation systems that were not included in the diesel-powered off-road equipment activity database developed during this project. A final difference, described in Chapter 2, is the OSMIS problem of incorrectly reporting the activity of non-aviation-related equipment, for which activity is reported in hours.

A major problem was discovered with HQRADDS when mobility fuel usage reports were generated. Many of the top fuel-consuming installations from the OSMIS data did not show any usage in HQRADDS. Figure 30 is the Installation Fuel Consumption report for the Army in FY2003 showing installation fuel consumption data from OSMIS. The top six installations on this report did not show any mobility fuel consumption in HQRADDS for FY2001–2003 when these installations obviously used large amounts of fuel in their vehicles during this time period. For this reason, it was impossible to do a broad-based comparison of Major Army Commands. Instead, comparisons were done for installations that did show usage in both HQRADDS and OSMIS.

Fuel Consumption and Inventory Summary by Installation

Report Criteria:					
	Service: USA	**Year:** 2003	**Installation:** All		
	Manufacturer: All		**Model #** All		
	Equipment: All				

Location:	Service	Average Inventory	Fuel Consumption (gal)	% of Total	Running Total
FT HOOD	USA	14,604	9,572,482	15.7%	15.7%
FT CARSON	USA	4,666	5,333,873	8.8%	24.5%
FT LEWIS	USA	5,023	3,225,402	5.3%	29.8%
FT RILEY	USA	2,786	2,195,537	3.6%	33.4%
FT BRAGG	USA	10,170	2,126,286	3.5%	36.9%
FT STEWART	USA	3,606	2,125,031	3.5%	40.4%
FT CAMPBELL	USA	5,687	2,028,769	3.3%	43.8%
FT IRWIN	USA	3,776	1,565,684	2.6%	46.4%
FT SILL	USA	3,015	1,006,598	1.7%	48.0%
FT POLK	USA	3,326	1,006,546	1.7%	49.7%
FT KNOX	USA	2,000	815,362	1.3%	51.0%
FT BLISS	USA	2,791	780,603	1.3%	52.3%
FT BENNING	USA	1,840	699,263	1.2%	53.4%
FT LEONARD WOOD	USA	1,704	453,170	0.7%	54.2%

Figure 30. Installation fuel consumption in FY2003.

HQRADDS Annual Mobility reports were generated for Forts Campbell, Irwin, Sill, Polk, Knox, and Benning. These installations had the largest fuel consumptions in OSMIS from FY 2001–2003 and, in HQRADDS, also had reported fuel usage. Reports were also generated from HQRADDS that showed the type of petroleum product consumed for mobility purposes. With one exception, the installations all reported a much larger consumption of JP8 compared with diesel or gasoline. The exception to this consumption was Fort Polk, which reported larger usage of gasoline than JP8 and less overall usage than might have been expected from the OSMIS results. Since Fort Polk's data were not consistent with the other installations' data, it was not part of the comparison.

To achieve a better comparison, OSMIS fuel consumption reports for aviation systems were run for each of the installations being compared. The fuel consumptions were totaled from these reports and added to the fuel consumption reported in the installation fuel consumption report shown in Figure 30. HQRADDS reports fuel consumption in million British thermal units (MBtus), which was converted to gallons (gal) by assuming a heat content of 5.67 MBtu/barrel and 42 gal/barrel. Table 14 shows the results of this comparison. Most of the fuel consumption reported by OSMIS is lower than the HQRADDS data. This would be expected both because

OSMIS does not report generator and other nonvehicular equipment activity correctly and because many major training facilities purchase fuel used by equipment that belongs to visiting units using the training facilities. A conspicuous exception to this trend is the fuel usage information for Fort Campbell in FY2003, which showed a dramatic increase in usage in OSMIS and a dramatic decrease in usage in HQRADDS. Most of the usage data were in general agreement with each other and HQRADDS values were usually no more than twice the amount reported by OSMIS.

Table 14. Installation fuel usage in gallons as reported in OSMIS and HQRADDS.

	FY 2001	FY 2002	FY 2003
Fort Campbell			
OSMIS aviation	7,019,000	8,322,897	14,100,163
OSMIS off-road	1,419,316	1,156,600	2,028,769
OSMIS total	8,438,316	9,479,497	16,128,932
HQRADDS total mobility	11,525,111	12,853,519	7,960,770
Fort Irwin			
OSMIS aviation	480,832	587,172	629,282
OSMIS off-road	3,314,238	2,013,449	1,565,684
OSMIS total	3,795,070	2,600,621	2,194,966
HQRADDS total mobility	5,712,970	5,529,059	3,785,615
Fort Benning			
OSMIS aviation	331,049	591,795	363,130
OSMIS off-road	1,067,990	575,028	699,263
OSMIS total	1,399,039	1,166,823	1,062,393
HQRADDS total mobility	1,895,793	1,243,244	1,500,193
Fort Knox			
OSMIS aviation	275,321	274,944	0
OSMIS off-road	865,137	797,607	815,362
OSMIS total	1,140,458	1,072,551	815,362
HQRADDS total mobility	2,036,200	1,889,770	2,162,289
Fort Sill			
OSMIS aviation	NR	NR	NR
OSMIS off-road	863,823	908,681	1,006,598
OSMIS total	863,823	908,681	1,006,598
HQRADDS total mobility	1,207,237	1,445,733	1,257,074

NR – Not reported

Summary

The fuel consumption information for diesel engines used in Army and USMC off-road equipment provided useful information for developing an emission testing priority. Although there are more than 800 equipment items for the Army and USMC in the database, there are fewer than 200 engines used in this equipment. The data

analysis showed that the top ten most frequently used engines in the Army and USMC account for a large majority of the fuel usage. It should there-fore be possible to develop engine-specific emission information that can estimate emissions from a large percentage of military equipment.

The fuel usage comparison with HQRADDS was complicated by missing data in the HQRADDS system. However, a comparison with installations showing fuel usage in both OSMIS and HQRADDS provides some evidence that the OSMIS information is accurate.

6 Summary and Conclusions

The database for diesel-powered off-road equipment was prepared to allow researchers working on SERDP project WP-1336 to select and prioritize the equipment to be tested for air pollution emissions and to be a source of information for their engine emission estimation tool. The database has proved useful as a prioritization tool. The database contains activity information for all the military off-road equipment used by the Army and USMC, which represents the large majority of the DoD's off-road equipment. The database provides a link between the large population of specific equipment items and the much smaller population of diesel engines that power this equipment. Table 11 provides useful information for prioritizing DoD usage of off-road equipment. For vehicles, the HMMWV, HEMTT, 5-ton trucks, LAV, Stryker, FMTV, and the Bradley Fighting Vehicle all show up as important engine emission sources. M1A1 and M1A2 tanks are also large sources but are powered by a turbine engine that would probably not be classified as a diesel off-road source. Although generators are not listed as prominently in Table 11, they are artificially underrepresented because Army generator usage is not reported correctly in OSMIS. The data from the USMC portion of the Navy VAMOSC system indicate that 60-kW, 30-kW, and 10-kW generator sets are major engine emission sources and it is very likely that a similar level of usage occurs within the Army and throughout DoD.

The database will also be useful for the engine emission estimation tool being developed under WP-1336. The engine emission factors developed from WP-1336 will require data on equipment characteristics such as engine power and equipment usage such as vehicle miles traveled, hours of operation, or fuel consumption in order to estimate emissions. The database developed under this project will serve as the source of much of this required data.

Because of the user interface, the database will also be useful to a wider population not necessarily familiar with databases or MS Access. The interface allows users to view, find, sort, and filter data from all the database tables and analyze data through reports based upon user-provided criteria. The interface allows database access to anyone interested in obtaining or analyzing data about DoD fuels, off-road equipment, diesel engines, and off-road equipment usage. The database, the interface, and this report will be made available to anyone with DoD menu privileges in the permanent shared file library section of the DENIX website.

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Appendix: Engine Fuel Consumption With Equipment List Reports for All Services With Equipment Usage in FY2003

Fuel Consumption and Inventory Summary by Engine Model

Report Criteria: **Service:** All **Year:** 2003 **Installation:** All

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running %
GENERAL MOTORS	6.2L	94,928	14,743,248	17.3%	17.3%
ALLIED SIGNAL	AGT 1500	4,973	14,129,437	16.5%	33.8%
DETROIT DIESEL	8V92TA	12,693	10,223,560	12.0%	45.8%
CUMMINS ENGINE	NHC 250	23,525	7,112,306	8.3%	54.1%
DETROIT DIESEL	6V53T	5,451	4,812,455	5.6%	59.7%
CUMMINS ENGINE	6CTA8.3	12,142	4,409,017	5.2%	64.9%
CATERPILLAR	3126B	5,017	3,822,348	4.5%	69.3%
CATERPILLAR	3116 ATAAC	11,952	3,536,020	4.1%	73.5%
CUMMINS ENGINE	VTA-903T	3,493	2,566,129	3.0%	76.5%
ALLIS CHALMERS	3500	1,215	2,554,053	3.0%	79.5%
DETROIT DIESEL	8V-92	1,298	2,175,720	2.5%	82.0%
CUMMINS ENGINE	VT400	1,161	2,167,047	2.5%	84.6%
CUMMINS ENGINE	NTC 400	3,820	1,893,010	2.2%	86.8%
HERCULES ENGINE	D298ERX37	1,439	1,127,779	1.3%	88.1%
CONTINENTAL	LDS465-1	10,036	1,018,161	1.2%	89.3%
ONAN DIV	DN4M1	3,864	1,004,081	1.2%	90.5%
CONTINENTAL	AVDS1790-2DR	1,889	899,277	1.1%	91.5%
GENERAL MOTORS	6.5L	5,701	823,044	1.0%	92.5%
JOHN DEERE	6059T	2,453	660,040	0.8%	93.2%
DETROIT DIESEL	DDEC II	1,375	618,550	0.7%	94.0%
JOHN DEERE	6466 6.8L	499	615,823	0.7%	94.7%
CONTINENTAL	LD465-1	6,278	610,581	0.7%	95.4%
DETROIT DIESEL	6V53	8,420	442,514	0.5%	95.9%
CUMMINS ENGINE	V903C	408	429,250	0.5%	96.4%
MERCEDES BENZ	OM 352	1,901	409,317	0.5%	96.9%
CATERPILLAR	3306	278	400,886	0.5%	97.4%
CATERPILLAR	3208	126	321,888	0.4%	97.7%
JI CASE	G188D	152	285,250	0.3%	98.1%
DETROIT DIESEL	8V71T	1,592	278,067	0.3%	98.4%
ONAN DIV	Q106M	3,737	241,344	0.3%	98.7%
PERKINS	704-30T	431	206,630	0.2%	98.9%
CATERPILLAR	3304	1,590	199,456	0.2%	99.2%

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running %
CATERPILLAR	3408T	421	160,027	0.2%	99.3%
CONTINENTAL	AVDS1790-2DA	24	125,688	0.1%	99.5%
JOHN DEERE	4039T	795	109,676	0.1%	99.6%
CONTINENTAL	AVDS1790-2D	415	105,966	0.1%	99.7%
CUMMINS ENGINE	4B3.9	2,385	72,946	0.1%	99.8%
JI CASE	6T590	76	37,084	0.0%	99.9%
MERCEDES BENZ	OM 603-950	501	35,841	0.0%	99.9%
CATERPILLAR	3406	907	28,081	0.0%	100.0%
MERCEDES BENZ	OM402AT	70	23,293	0.0%	100.0%
DEUTZ	F4L-912	50	8,279	0.0%	100.0%
ONAN DIV	DJC-12315T	308	5,487	0.0%	100.0%
YORK SHIPLEY	VY-7-8DD	192	1,226	0.0%	100.0%
CUMMINS ENGINE	6BT5.9-C	1,437	325	0.0%	100.0%
CATERPILLAR	3306T	888	309	0.0%	100.0%
DETROIT DIESEL	453N	346	294	0.0%	100.0%
CATERPILLAR	D342	167	227	0.0%	100.0%
JI CASE	504BD	1,000	166	0.0%	100.0%
DETROIT DIESEL	6V92TC/6-71	9	144	0.0%	100.0%
CATERPILLAR	D333CT	1,183	126	0.0%	100.0%
ONAN DIV	DJC99E/9487	1,486	123	0.0%	100.0%
CONTINENTAL	AVDS1790-2C	7	119	0.0%	100.0%
CATERPILLAR	C240	870	84	0.0%	100.0%
HERCULES ENGINE	D198ERX51	949	77	0.0%	100.0%
ISUZU	C240	1,416	76	0.0%	100.0%
CATERPILLAR	3046T	55	67	0.0%	100.0%
INTER HARV	DT-817C	59	67	0.0%	100.0%
CUMMINS ENGINE	6BT5.9	1,262	52	0.0%	100.0%
DETROIT DIESEL	4-71	6	21	0.0%	100.0%
CUMMINS ENGINE	V8 265 2380	24	14	0.0%	100.0%
ONAN DIV	DN2M	3,761	12	0.0%	100.0%
CATERPILLAR	3126 HEUI	242	9	0.0%	100.0%
CONTINENTAL	AVDS1790-2A, D,	2	4	0.0%	100.0%
ONAN DIV	Q106D	3,989	3	0.0%	100.0%
CATERPILLAR	3208 V8	12	2	0.0%	100.0%
YANMAR	L70A-D/DE	11	0	0.0%	100.0%
CATERPILLAR	D333C (T)	0			100.0%

Fuel Consumption, Activity, and Inventory for Engines and Equipment

Report Criteria: **Year:** 2003 **Service:** All **Installation:** All
Manufacturer: All **Model #:** All

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
GENERAL MOTORS	*6.2L*	*94,928*	*14,743,248*	*17.3%*	*17.3%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK UTIL TROOP/CGO HMMWV M998	USA	6,786,528	100,666,834	miles	41,752
TRUCK UTIL ARMT CARR ARMORED HMMWV M1025	USA	987,357	14,645,802	miles	5,782
TRUCK UTIL TROOP/CGO HMMWV M998A1	USA	939,319	13,933,233	miles	5,668
AN/TWQ-1 - Avenger	USMC	856,541	77,837	hours	213
TRUCK UTIL TACTICAL CUCV M1009	USA	848,751	10,791,262	miles	4,631
TRUCK UTIL TROOP/CGO HMMWV M1038	USA	678,580	10,065,601	miles	4,140
TRK CARGO, HMMWV M998/1038	USMC	544,077	11,670,216	miles	7,634
TRUCK UTIL HVY VARIANT HMMWV M1097	USA	490,096	7,269,759	miles	2,527
TRUCK UTIL ARMT CARR ARMORED HMMWV M1026	USA	421,208	6,247,923	miles	2,268
TRUCK UTIL TOW CARRIER ARMORED HMMWV M966	USA	376,614	5,586,441	miles	2,045
TRUCK CARGO TAC CUCV M1008	USA	359,257	4,567,690	miles	2,605
TRUCK AMBULANCE 4LTR HMMWV M997	USA	313,435	4,649,292	miles	2,755
TRUCK UTIL S250 SHELTER HMMWV M1037	USA	285,787	4,239,177	miles	5,048
TRUCK CARGO TAC CUCV M1008A1	USA	237,710	3,022,312	miles	1,880
TRUCK TAC SHELTER CUCV M1028	USA	224,487	2,854,197	miles	1,236
Radio Set, AN/MRC-145A	USMC	151,759	133,576	hours	1,196
TRUCK ARMT HMMWV M1043/1044	USMC	71,965	1,457,577	miles	1,158
TRUCK HMMWV TOW CARR M1045/10	USMC	44,258	880,498	miles	603
TRUCK AMBULANCE 2LTR HMMWV M996	USA	28,054	416,140	miles	277
TRUCK UTILITY SHELTER M1037	USMC	27,377	513,171	miles	194
TRUCK AMBULANCE 4LTR HMMWV M997	USMC	20,578	394,436	miles	425
TRUCK TAC SHELTER CUCV M1028A1	USA	19,933	253,439	miles	133
TRUCK AMB SOFT TOP HMMWV, M10	USMC	13,322	271,045	miles	253
Radio Terminal Set, AN/MRC-142	USMC	6,003	56,301	hours	355
TRUCK AMBULANCE: TACTICAL 5/4 TON 4X4 M1010	USA	4,431	56,333	miles	70
TRUCK UTIL HVY VARIANT HMMWV M1097	USMC	2,620	2,397	hours	20
TRUCK AMBULANCE 4LTR HMMWV M997A1	USA	1,205	17,870	miles	11
TRUCK UTIL TROOP/CGO HMMWV M1038A1	USA	986	14,621	miles	16
TRUCK UTIL ARMT CARR ARMORED HMMWV M1025A1	USA	799	11,852	miles	25

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK UTIL ARMT CARR ARMORED HMMWV M1026A1	USA	124	1,832	miles	5
TRUCK AMBULANCE 2LTR HMMWV M996A1	USA	86	1,283	miles	3

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ALLIED SIGNAL	*AGT 1500*	*4,973*	*14,129,437*	*16.5%*	*33.8%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TANK COMBAT 120MM M1A1	USA	5,991,002	778,393	miles	3,199
TANK COMBAT 120MM M1A2	USA	4,726,652	600,960	miles	598
TANK COMBAT FULL TRACKED 120MM M1A1	USMC	3,106,268	358,218	hours	403
TANK COMBAT 105MM M1IP	USA	305,515	43,645	miles	773

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*8V92TA*	*12,693*	*10,223,560*	*12.0%*	*45.8%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK TRACTOR HET M1070	USA	1,971,948	5,484,481	miles	2,008
TRUCK TANK FS 2500GL HEMTT M978	USA	1,593,120	3,832,100	miles	1,945
TRUCK CARGO 10TON HEMTT M977	USA	1,510,790	3,634,062	miles	1,742
TRUCK WRECKER 10TON HEMTT M984A1	USA	1,382,979	3,326,625	miles	1,590
TRUCK TANK FS 2500GL HEMTT WW M978	USA	1,058,844	2,546,948	miles	1,124
TRUCK CARGO HEAVY PLS TRANS M1074	USA	894,569	2,151,802	miles	1,252
TRUCK CARGO 10TON HEMTT M985	USA	746,071	1,794,603	miles	1,198
TRUCK CARGO 10TON HEMTT WW M977	USA	405,229	974,740	miles	639
TRUCK CARGO PALLETALIZED LOAD HNDG M1120	USA	273,079	656,866	miles	284
TRUCK TRACTOR 10TON HEMTT WW M983	USA	179,322	431,343	miles	345
TRUCK CARGO 10TON HEMTT WW M985	USA	138,393	332,892	miles	254
TRUCK TRACTOR HET 22.5 TON WW M911	USA	25,869	74,268	miles	218
TRUCK CARGO 10TON HEMTT M985E1	USA	23,079	55,515	miles	55
TRUCK WRECKER 10TON HEMTT M984	USA	20,268	48,752	miles	39

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*NHC 250*	*23,525*	*7,112,306*	*8.3%*	*54.1%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK CARGO 5TON DROPSIDE M923A1	USMC	1,770,496	11,532,135	miles	4,481
TRUCK CARGO 5TON DROPSIDE M923	USA	1,030,758	5,396,320	miles	2,556
TRUCK TRACTOR 5TON M818	USA	745,689	2,885,491	miles	3,127
TRUCK TRACTOR 5TON M931	USA	412,067	2,157,290	miles	1,255
TRUCK CARGO 5TON DROPSIDE M813A1	USA	297,024	1,149,354	miles	1,248
TRUCK CARGO 5TON DROPSIDE M923A1	USA	249,332	1,305,327	miles	759
TRUCK CARGO 5TON DROPSIDE WW M925	USA	245,067	1,282,998	miles	922
TRUCK DUMP 5TON M817	USA	244,412	945,767	miles	836
TRUCK DUMP 5TON M929	USA	234,666	1,228,545	miles	661
TRUCK TRACTOR 5TON M931A1	USA	214,718	1,124,111	miles	623
TRUCK, 5TON M927/M928	USMC	179,238	1,217,848	miles	553
TRUCK WRECKER 5TON WW M816	USA	164,582	636,861	miles	799
TRUCK DUMP 5TON WW M817	USA	145,216	561,923	miles	450
TRUCK CARGO 5TON DROPSIDE WW M925A1	USA	137,840	721,635	miles	400
TRUCK TRACTOR 5TON WW M818	USA	95,077	367,905	miles	566
TRUCK VAN EXPANSIBLE 5TON M934	USA	91,878	481,007	miles	331
TRUCK WRECKER 5TON WW M936	USA	90,277	472,626	miles	395
TRUCK, MAINTENANCE/TELEPHONE	USMC	87,047	27,046	hours	14
TRUCK CARGO 5TON LWB WW M813	USA	76,303	295,260	miles	298
TRUCK CARGO 5TON LWB M813	USA	65,909	255,040	miles	497
TRUCK CARGO 5TON DROPSIDE WW M813A1	USA	61,495	237,957	miles	419
TRUCK TRACTOR 5TON WW M932A1	USA	59,759	312,855	miles	93
TRUCK CARGO 5TON XLWB M927A1	USA	49,522	259,261	miles	180
TRK TRACTOR, M818/931	USMC	49,175	460,112	miles	288
WRECKER M816/M936	USMC	49,048	462,931	miles	233
TRUCK VAN EXPANSIBLE 5TON M820	USA	42,016	162,585	miles	174
TRUCK TRACTOR 5TON M932	USA	41,415	216,821	miles	149
TRK DUMP M817/M929/M930	USMC	38,103	502,279	miles	435
TRUCK CARGO 5TON XLWB M814	USA	35,763	138,388	miles	149
TRUCK CARGO 5TON XLWB M927	USA	32,077	167,935	miles	169
TRUCK CARGO 5TON XLWB WW M928	USA	21,823	114,249	miles	85
TRUCK DUMP 5TON M929A1	USA	21,461	112,353	miles	172
TRUCK VAN EXPANSIBLE 5TON M934A1	USA	14,552	76,186	miles	90

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK VAN EXPANSIBLE 5TON M820A2	USA	6,065	23,467 miles	34
TRUCK CARGO 5TON XLWB WW M814	USA	5,632	21,792 miles	14
TRUCK CARGO 5TON XLWB WW M928A1	USA	4,451	23,300 miles	30
TRUCK WRECKER 5TON WW M936A1	USA	1,294	6,772 miles	18
TRUCK DUMP 5TON WW M930	USA	900	4,713 miles	12
TRUCK VAN EXPANSIBLE 5TON M935A1	USA	77	402 miles	1
TRUCK VAN EXPANSIBLE 5TON M935	USA	43	226 miles	4
TRUCK CARGO 5TON LWB M924	USA	40	207 miles	3
TRUCK TRAC/WRECKER 5TON WW M819	USA	2	8 miles	2

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*6V53T*	*5,451*	*4,812,455*	*5.6%*	*59.7%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
LIGHT ARMORED VEHICLE (25)	USMC	1,995,654	479,418 hours	361
LIGHT ARMORED VEHICLE LOGISTICS	USMC	700,066	122,354 hours	91
LIGHT ARMORED VEHICLE ANTI-TANK	USMC	458,437	78,665 hours	90
LIGHT ARMORED VEHICLE COMMAND	USMC	441,783	59,941 hours	49
CARRIER PERSONNEL FT (RISE) M113A3	USA	429,299	734,762 miles	3,066
LIGHT ARMORED VEHICLE MORTAR	USMC	245,779	43,182 hours	47
LIGHT ARMORED VEHICLE RECOVERY	USMC	190,808	40,343 hours	35
Mobile EW Support System, AN/MLQ-36	USMC	120,528	7,246 hours	6
CARRIER ARMORED COMMAND POST M1068A3	USA	87,542	149,831 miles	451
CARRIER COMMAND POST FT M577A3	USA	72,163	123,510 miles	351
CARRIER CARGO TRACKED 6TON M548A3	USA	46,033	78,787 miles	773
ARMORED RECON AB ASSAULT VEH M551A1	USA	20,043	27,444 miles	77
CARRIER SMOKE GENERATOR FT M1059A3	USA	4,320	7,393 miles	54
CARRIER MORTAR 120MM M1064A3	USA	0	117,741 miles	0

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*6CTA8.3*	*12,142*	*4,409,017*	*5.2%*	*64.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK CARGO 5TON DROPSIDE M923A2	USA	2,040,788	10,684,124	miles	5,687
TRUCK TRACTOR 5TON M931A2	USA	1,091,093	5,712,191	miles	2,755
TRUCK DUMP 5TON M929A2	USA	369,062	1,932,149	miles	912
TRUCK CARGO 5TON DROPSIDE WW M925A2	USA	358,786	1,878,350	miles	1,108
TRUCK WRECKER 5TON WW M936A2	USA	175,667	919,670	miles	629
TRUCK TRACTOR 5TON WW M932A2	USA	114,609	600,012	miles	251
ARMORED SECURITY VEHICLE M1117	USA	90,763	77,672	miles	32
TRUCK VAN EXPANSIBLE 5TON M934A2	USA	85,543	447,843	miles	461
TRUCK CARGO 5TON XLWB M927A2	USA	32,458	169,925	miles	116
TRUCK DUMP 5TON WW M930A2	USA	32,282	169,006	miles	103
TRUCK CARGO 5TON XLWB WW M928A2	USA	17,967	94,060	miles	88

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3126B*	*5,017*	*3,822,348*	*4.5%*	*69.3%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
LIGHT ARMORED VEH INFANTRY CARRIER M1126	USA	1,131,193	264,242	miles	122
TRUCK CARGO MTV M1083A1	USA	720,045	3,769,647	miles	1,584
TRUCK TRACTOR MTV M1088A1	USA	653,007	3,418,682	miles	1,315
LIGHT ARMORED VEHICLE MORTAR CARR IVC M1129	USA	228,754	53,436	miles	30
TRUCK CARGO LMTV M1078A1	USA	172,944	1,184,003	miles	857
LIGHT ARMORED VEHICLE RECON ICV M1127	USA	168,304	39,315	miles	32
LIGHT ARMORED VEHICLE ATGM ICV M1134	USA	166,386	38,867	miles	32
LIGHT ARMORED VEHICLE COMMANDER'S VEH M1130	USA	130,653	30,520	miles	20
TRUCK WRECKER MTV WW M1089A1	USA	90,551	474,059	miles	229
TRUCK CARGO MTV W/MHE M1084A1	USA	76,795	402,042	miles	217
LIGHT ARMORED VEHICLE MEDEVAC M1133 ICV	USA	61,324	14,325	miles	16
TRUCK CARGO MTV WW M M1083A1	USA	60,383	316,124	miles	169
LIGHT ARMORED VEHICLE FIRE SPT (FSV)(ICV) M1131	USA	59,098	13,805	miles	14
TRUCK CARGO MTV LWB M1085A1	USA	40,741	213,291	miles	66
LIGHT ARMORED VEHICLE ENGINEER SPT VEH M1132	USA	24,662	5,761	miles	7
TRUCK CARGO LMTV WW M1078A1	USA	19,864	135,995	miles	149
TRUCK CARGO LMTV WW M1079A1	USA	10,352	70,871	miles	111
TRUCK DUMP MTV M1090A1	USA	5,517	28,881	miles	40
TRUCK DUMP MTV WW M1090A1	USA	1,776	9,297	miles	7

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3116 ATAAC*	*11,952*	*3,536,020*	*4.1%*	*73.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK CARGO LMTV M1078	USA	1,251,038	8,564,797	miles	4,043
TRUCK CARGO 21/2TON M35A3	USA	512,820	4,149,179	miles	2,665
TRUCK CARGO MTV M1083	USA	403,504	2,112,463	miles	770
TRUCK TRACTOR MTV M1088	USA	302,283	1,582,538	miles	818
TRUCK CARGO LMTV LAPES/AD M1081	USA	212,884	1,457,440	miles	608
TRUCK CARGO 21/2TON WW M35A3	USA	126,307	1,021,939	miles	671
TRUCK CARGO LMTV WW M1078	USA	111,270	761,771	miles	382
TRUCK CARGO MTV WW M1083	USA	104,476	546,960	miles	249
TRUCK CARGO MTV LAPES/AD M1093	USA	89,858	470,434	miles	267
TRUCK CARGO MTV W/MHE M1084	USA	89,388	467,971	miles	154
TRUCK DUMP MTV M1090	USA	63,454	332,200	miles	228
TRUCK WRECKER MTV WW M1089	USA	60,336	315,876	miles	208
TRUCK CARGO LMTV LAPES/AD WW M1081	USA	57,677	394,863	miles	147
TRUCK DUMP MTV LAPES/AD M1094	USA	50,194	262,781	miles	150
TRUCK CARGO 21/2TON D/S M35A3C	USA	31,343	253,593	miles	200
TRUCK CARGO MTV LAPES/AD WW M1093	USA	15,098	79,044	miles	72
TRUCK CARGO MTV LWB W/MHE M1086	USA	14,160	74,132	miles	36
TRUCK TRACTOR MTV WW M1088	USA	9,351	48,955	miles	50
TRUCK CARGO 21/2TON LWB M36A3	USA	7,827	63,329	miles	66
TRUCK CARGO MTV LWB M1085	USA	7,818	40,930	miles	42
TRUCK CARGO 21/2TON D/S WW M35A3C	USA	5,363	43,391	miles	77
TRUCK DUMP MTV LAPES/AD WW M1094	USA	5,025	26,309	miles	15
TRUCK DUMP MTV WW M1090	USA	2,467	12,915	miles	6
TRUCK CARGO 21/2TON LWB WW M36A3	USA	1,540	12,457	miles	24
TRUCK CARGO MTV LWB WW M1085	USA	540	2,827	miles	4

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*VTA-903T*	*3,493*	*2,566,129*	*3.0%*	*76.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
INFANTRY FIGHTING VEHICLE M2A2 HS	USA	1,615,043	1,382,104	miles	1,626
CAVALRY FIGHTING VEHICLE M3A2	USA	267,809	229,183	miles	621
INFANTRY FIGHTING VEHICLE M2A3	USA	252,017	215,668	miles	171
MULTIPLE LAUNCH ROCKET SYSTEM M993	USA	177,110	151,565	miles	425
CAVALRY FIGHTING VEHICLE M3A3	USA	124,989	106,962	miles	67
BRADLEY - LINEBACKER	USA	95,819	81,999	miles	85
INFANTRY FIGHTING VEHICLE M2	USA	31,705	27,132	miles	418
CAVALRY FIGHTING VEHICLE M3A1	USA	1,637	1,401	miles	80

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ALLIS CHALMERS	*3500*	*1,215*	*2,554,053*	*3.0%*	*79.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
GEN ST DED 60KW 60HZ MEP006A	USMC	2,553,774	766,395	hours	609
GEN ST DED 60KW 400HZ MEP115A	USA	279	48	hours	606

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*8V-92*	*1,298*	*2,175,720*	*2.5%*	*82.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
LOGISTICS VEHICLE SYSTEM 12 1/2 TON MK 48	USMC	2,175,720	1,858,209	hours	1,298

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*VT400*	*1,161*	*2,167,047*	*2.5%*	*84.6%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
ASSAULT AMPHIBIOUS VEHICLE, PERSONNEL AAVP7A1 (2)	USMC	1,942,158	403,284	hours	1,040
ASSAULT AMPHIBIOUS VEHICLE, RECOVERY AAVR7A1 (2)	USMC	124,603	24,229	hours	51
ASSAULT AMPHIBIOUS VEHICLE, COMMAND AAVC7A1 (1)	USMC	100,286	19,840	hours	70

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*NTC 400*	*3,820*	*1,893,010*	*2.2%*	*86.8%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK TRACTOR LINE HAUL M915A1	USA	1,112,346	6,187,423	miles	1,803
TRUCK TRACTOR LINE HAUL M915	USA	380,276	2,115,284	miles	764
TRUCK TRACTOR MET M920	USA	215,250	1,197,327	miles	707
TRUCK DUMP 20TON 12 CU YD C/S M917	USA	153,608	501,978	miles	408
CONCRETE MOBILE MIXER TM 8 CU YD M919	USA	28,956	161,066	miles	87
DISTRIBUTOR BITUMIN MDL D63 TM M918	USA	2,575	14,324	miles	51

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
HERCULES ENGINE	*D298ERX37*	*1,439*	*1,127,779*	*1.3%*	*88.1%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
GEN ST DED 30KW 60HZ MEP 005A	USMC	1,127,608	719,144	hours	1,010
GEN ST DED 30KW 400HZ MEP114A	USA	171	60	hours	429

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*LDS465-1*	*10,036*	*1,018,161*	*1.2%*	*89.3%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK CARGO 21/2TON M35A2	USA	1,004,378	8,126,330	miles	9,700
TRUCK TRACTOR 5TON M52A2	USA	5,364	26,522	miles	157
TRUCK DUMP 5TON M51A2	USA	3,427	16,946	miles	66
TRUCK DUMP 5TON WW M51A2	USA	2,717	13,432	miles	37
TRUCK CARGO 21/2TON M35A1	USA	1,266	10,241	miles	8
TRUCK CARGO 5TON LWB M54A2	USA	431	2,133	miles	19
TRUCK TRACTOR 5TON WW M52A2	USA	263	1,299	miles	11
TRUCK CARGO 5TON LWB WW M54A2	USA	261	1,292	miles	11
TRUCK CARGO 5TON XLWB WW M55A2	USA	48	236	miles	3
TRUCK CARGO 5TON LWB M54	USA	2	9	miles	7
TRUCK TRACTOR 5TON WW M52	USA	2	9	miles	3
TRUCK CARGO 5TON DROPSIDE M54A1C	USA	1	4	miles	2
TRUCK CARGO 5TON LWB WW M54	USA	0	2	miles	2
TRUCK CARGO 5TON LWB M54A1	USA	0	2	miles	2
TRUCK TRACTOR 5TON M52	USA	0	2	miles	2
TRUCK TRACTOR 5TON M52A1	USA	0	2	miles	2
Generic TRUCK CARGO 5TON M54-LDS465-1	USA	0	2	miles	2
TRUCK CARGO 21/2TON WW M35A1	USA	0	2	miles	2

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*DN4M1*	*3,864*	*1,004,081*	*1.2%*	*90.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
GEN ST DED 10KW 60HZ MEP803A	USMC	993,789	1,316,152	hours	1,213
GEN ST DED 10KW 400HZ MEP-813A	USMC	10,248	19,573	hours	130
GEN ST DED 10KW 60HZ TQ MEP803A	USA	32	32	hours	2,278
GEN ST DED 10KW 400HZ TQ MEP813A	USA	12	12	hours	243

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*AVDS1790-2DR*	*1,889*	*899,277*	*1.1%*	*91.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
RECOVERY VEHICLE MEDIUM M88A1	USA	524,348	263,655	miles	1,706
RECOVERY VEH MEDIUM FULL TRACK M88A1	USMC	270,641	24,676	hours	62
RECOVERY VEHICLE HEAVY M88A2	USA	104,289	52,439	miles	121

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
GENERAL MOTORS	*6.5L*	*5,701*	*823,044*	*1.0%*	*92.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK UTIL HVY VARNT HMMWV M1097A2	USA	338,584	5,022,335	miles	3,562
TRUCK UTIL EXP CAPACITY UP-ARMORED HMMWV M1114	USA	334,581	4,962,948	miles	1,402
TRUCK UTIL ARMT CARR ARMORED HMMWV M1025A2	USA	149,878	2,223,185	miles	732
TRUCK AMBULANCE 4LTR HMMWV M997A2	USA	1	8	miles	2
TRUCK UTIL UP-ARMORED HMMWV M1109	USA	0	4	miles	3

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JOHN DEERE	*6059T*	*2,453*	*660,040*	*0.8%*	*93.2%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK FORKLIFT EXTENDABLE B	USMC	357,544	227,183	hours	492
MEP-816A 400HZ (60 KW GENERATOR)	USMC	302,327	158,341	hours	121
GEN ST DED 60KW 60HZ TQ MEP806A	USA	92	20	hours	623
GEN ST DED 60KW 400HZ TQ MEP816A	USA	41	8	hours	200
TRUCK FL DED 10000 LB ROUGH TERRAIN(1)	USA	37	33	hours	1,017

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*DDEC II*	*1,375*	*618,550*	*0.7%*	*94.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRUCK TRACTOR LINE HAUL M915A2	USA	384,676	2,139,761	miles	763
TRUCK DUMP 20TON 12 CU YD C/S M917A1	USA	188,327	1,047,569	miles	462
TRUCK DUMP 20TON 12 CU YD C/S M917A1 W/MCS	USA	45,547	253,356	miles	150

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JOHN DEERE	*6466 6.8L*	*499*	*615,823*	*0.7%*	*94.7%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR RT ARTICULAT, STR 6 LOADER SCOOP TYPE	USMC	615,823	182,300 hours	499

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*LD465-1*	*6,278*	*610,581*	*0.7%*	*95.4%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK CARGO 21/2TON WW M35A2	USA	362,237	2,930,823 miles	3,715
TRUCK VAN SHOP 21/2TON M109A3	USA	134,003	1,084,203 miles	1,174
TRUCK CARGO 21/2TON D/S M35A2C	USA	85,722	693,572 miles	962
TRUCK VAN SHOP 21/2TON WW M109A3	USA	12,361	100,009 miles	46
TRUCK CARGO 21/2TON XLWB M36A2	USA	6,434	52,057 miles	114
Generic TRUCK CARGO 21/2TON M35-LD465-1	USA	5,156	41,719 miles	90
TRUCK CARGO 21/2TON D/S WW M35A2C	USA	1,967	15,912 miles	44
TRUCK CARGO 21/2TON XLWB WW M36A2	USA	1,176	9,511 miles	37
TRUCK TANK FS 21/2TON M49A2C	USA	1,110	8,983 miles	54
TRUCK TANK WATER 21/2TON M50A3	USA	414	3,349 miles	33
TRUCK TANK WATER 21/2TON M50A2	USA	2	13 miles	5
TRUCK TANK FS 21/2TON M49A1C	USA	0	4 miles	2
TRUCK TANK FS 21/2TON WW M49A2C	USA	0	2 miles	2

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*6V53*	*8,420*	*442,514*	*0.5%*	*95.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
CARRIER PERSONNEL FT M113A2	USA	225,921	386,672	miles	3,344
CARRIER COMMAND POST FT M577A2	USA	114,252	195,547	miles	2,866
CARRIER PERSONNEL FIRE SPT M981	USA	46,693	74,208	miles	792
CARRIER MORTAR 120MM M1064	USA	39,838	68,185	miles	553
COMBAT VEHICLE ANTI-TANK ITV M901A1	USA	9,641	16,501	miles	527
CARRIER SMOKE GENERATOR FT M1059	USA	4,998	8,555	miles	102
CARRIER FT COMMAND AND CONTROL VEHICLE C2V M4	USA	932	798	miles	10
CRANE TRUCK MOUNTED 25TON MT250	USA	232	68	hours	220
CARRIER MORTAR 107MM SP M106A2	USA	6	10	miles	6

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*V903C*	*408*	*429,250*	*0.5%*	*96.4%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
ARMORED COMBAT EARTHMOVER M9	USMC	316,284	76,624	hours	101
ARMORED COMBAT EARTHMOVER M9	USA	112,966	84,487	miles	307

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
MERCEDES BENZ	*OM 352*	*1,901*	*409,317*	*0.5%*	*96.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRACTOR WHEEL DED 4X4 EXCAVATOR FLU419	USMC	409,178	124,308	hours	120
TRACTOR WHEEL DED 4X4 EXCAVATOR	USA	101	32	hours	1,669
TRACTOR WHEEL DED 4X4 HMMH FLU10344	USA	38	12	hours	112

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3306*	*278*	*400,886*	*0.5%*	*97.4%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity		Inventory
TRACTOR, MED, FULL TRACK, D	USMC	400,861	88,939	hours	245
TRACTOR FT DED D7H	USA	25	4	hours	33

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3208*	*126*	*321,888*	*0.4%*	*97.7%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CRANE HIGH SPEED	USMC	321,888	92,948 hours	126

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JI CASE	*G188D*	*152*	*285,250*	*0.3%*	*98.1%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR, FULL TRACK, 1150E	USMC	285,250	83,431 hours	152

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*8V71T*	*1,592*	*278,067*	*0.3%*	*98.4%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
HOWITZER MEDIUM SP 155MM M109A6	USA	211,409	235,193 miles	623
HOWITZER MEDIUM SP 155MM M109A5	USA	40,704	45,283 miles	556
CARRIER CARGO AMMO FT M992A1	USA	21,660	21,906 miles	34
RECOVERY VEHICLE LIGHT M578	USA	4,290	4,492 miles	377
HOWITZER HEAVY SP 8IN M110A2	USA	4	3 miles	2

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*Q106M*	*3,737*	*241,344*	*0.3%*	*98.7%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN ST DED 3KW 60HZ MEP 16B	USMC	241,309	768,720 hours	1,359
GEN ST DED 3KW 60HZ	USA	22	36 hours	376
GEN ST DED 3KW 60HZ MEP016B	USA	13	40 hours	2,002

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
PERKINS	*704-30T*	*431*	*206,630*	*0.2%*	*98.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK, FORKLIFT LCRT 4000 LBS	USMC	206,630	106,193 hours	431

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3304*	*1,590*	*199,456*	*0.2%*	*99.2%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GRADER RD MOTOR, 130-G	USMC	186,098	70,922 hours	105
ROLLER COMPACTOR 563D	USMC	13,064	6,750 hours	45
GRADER ROAD MTRZD DED MDL CAT130G	USA	176	28 hours	1,270
LOADER SCOOP TYPE DED 950BNS	USA	118	14 hours	170

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3408T*	*421*	*160,027*	*0.2%*	*99.3%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL 50000 LB CONTAINER HANDLER	USMC	159,964	31,630 hours	87
TRUCK FL 50000LB CONT HDLR DV43 RT	USA	63	12 hours	334

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*AVDS1790-2DA*	*24*	*125,688*	*0.1%*	*99.5%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
BRIDGE ARMORED, M60A1 SCISS	USMC	125,688	17,032 hours	24

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JOHN DEERE	*4039T*	*795*	*109,676*	*0.1%*	*99.6%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN, MEP-114A (30 KW GENERATOR)	USMC	109,618	91,802 hours	64
GEN ST DED 30KW 50/60HZ TQ MEP805A	USA	27	11 hours	637
TRACTOR FT DED MDL 550C	USA	22	7 hours	20
GEN ST DED 30KW 400HZ TQ MEP815A	USA	8	3 hours	74

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*AVDS1790-2D*	*415*	*105,966*	*0.1%*	*99.7%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
BRIDGE LAUNCHER M48/M60 TANK SERIES	USA	105,966	50,704 miles	415

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*4B3.9*	*2,385*	*72,946*	*0.1%*	*99.8%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CRANE, RT, LIGHT HYDRAULIC	USMC	72,700	75,729 hours	144
TRUCK FL DED 4000LB RT MDL MK4	USA	126	24 hours	1,626
CRANE WHEEL MTD HYD LT 7-1/2 TON LRT 110 W/CAB	USA	120	49 hours	615

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JI CASE	*6T590*	*76*	*37,084*	*0.0%*	*99.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
LOADER SCOOP TYPE FT	USMC	37,084	23,816 hours	76

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
MERCEDES BENZ	*OM 603-950*	*501*	*35,841*	*0.0%*	*99.9%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CARRIER CARGO FT SUSV M973A1	USA	35,841	109,996 miles	501

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3406*	*907*	*28,081*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
SCRAPER-TRACTOR, WHEELED, 6	USMC	27,980	5,596 hours	44
SCRAPER EARTH MVG SP 621B	USA	101	16 hours	863

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
MERCEDES BENZ	*OM402AT*	*70*	*23,293*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
FOX NBC RECON SYSTEM VEHICLE M93A1	USA	23,293	71,486 miles	70

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DEUTZ	*F4L-912*	*50*	*8,279*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
DITCHING MACHINE	USMC	8,279	25,968 hours	50

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*DJC-12315T*	*308*	*5,487*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
SEMITRAILER TANK 5000 GAL M970	USMC	5,487	9,430 hours	308

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
YORK SHIPLEY	*VY-7-8DD*	*192*	*1,226*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
BATH, SHOWER UNIT	USMC	1,226	514 hours	192

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*6BT5.9-C*	*1,437*	*325*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL DED 6000LB AMMO HDLG VRRTF	USA	325	62 hours	1,437

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3306T*	*888*	*309*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR FT DED D7F DV29	USA	309	49 hours	888

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*453N*	*346*	*294*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL DED 6000LB MLT-6	USA	294	56 hours	346

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*D342*	*167*	*227*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR FT DED CAT D8K-8 S-8	USA	227	36 hours	167

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
JI CASE	*504BD*	*1,000*	*166*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
LOADER SCOOP TYPE DED JI CASE MW24C	USA	166	45 hours	1,000

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*6V92TC/6-71*	*9*	*144*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CRANE TRUCK MOUNTED 140T	USA	144	4 hours	9

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*D333CT*	*1,183*	*126*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR FT DED LW SP(1)	USA	126	20 hours	1,165
TRACTOR FT DED D7R	USA	0	0 hours	18

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*DJC99E/9487*	*1,486*	*123*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN ST DED 10KW 60HZ MEP003A	USA	123	100 hours	1,486

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*AVDS1790-2C*	*7*	*119*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TANK COMBAT 105MM M60A3 (TTS)	USA	119	57 miles	7

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*C240*	*870*	*84*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL DED 4000LB CBD HYS H40XL	USA	84	16 hours	870

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
HERCULES ENGINE	*D198ERX51*	*949*	*77*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN ST DED 15KW 60HZ PU405	USA	77	50 hours	949

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ISUZU	*C240*	*1,416*	*76*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL DED 6000LB CBD HYSTER H60X	USA	47	9 hours	572
GEN ST DED 15KW 50/60HZ TQ MEP804A	USA	15	10 hours	472
GEN ST DED 15KW 400HZ TQ MEP814A	USA	14	8 hours	372

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
INTER HARV	*DT-817C*	*59*	*67*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
LOADER SCOOP TYPE DED BUCK H100CRB	USA	67	8 hours	59

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3046T*	*55*	*67*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR FT DED D5BS1	USA	67	16 hours	55

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*6BT5.9*	*1,262*	*52*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRUCK FL DED 4000LB AMMO HDLG VRRTF	USA	52	10 hours	1,262

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
DETROIT DIESEL	*4-71*	*6*	*21*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CRANE SHOVEL CRAWLER 40T PH5060	USA	21	2 hours	6

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CUMMINS ENGINE	*V8 265 2380*	*24*	*14*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
CRANE WHEEL MOUNTED M320RT	USA	14	4 hours	24

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*DN2M*	*3,761*	*12*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN ST DED 5KW 60HZ TQ MEP802A	USA	12	20 hours	3,715
GEN ST DED 5KW 400HZ TQ MEP812A	USA	0	0 hours	46

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CATERPILLAR	*3126 HEUI*	*242*	*9*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
TRACTOR FULL TRACKED HIGH SPEED (DEUCE)	USA	9	8 hours	242

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
CONTINENTAL	*AVDS1790-2A, D,*	*2*	*4*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
COMBAT ENGINEER VEHICLE M728	USA	4	2 miles	2

Manufacturer	Model	Average Inventory	Fuel Consumption	% of Total	Running Total
ONAN DIV	*Q106D*	*3,989*	*3*	*0.0%*	*100.0%*

Equipment using this Engine

Nomenclature	Service	Fuel Usage (gal)	Activity	Inventory
GEN ST DED 3KW 60HZ MEP831	USA	3	8 hours	3,989

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14. ABSTRACT

A database of Department of Defense diesel engine powered off-road equipment was developed using Microsoft® Access database development tools. The database contains information about fuels, equipment, engines, inventories, usage, and fuel consumption that was obtained from many disparate sources. This database was developed to support the SERDP-funded project Characterization of Off-Road Emissions of Criteria Pollutants (WP-1336). The database was used to prioritize the equipment contained in the WP-1336 test matrix and will later be used as a source of information for the WP-1336 engine emission estimation tool. Data analysis has shown that the top ten fuel consuming engines account for more than 90 percent of fuel usage for the Army and more than 80 percent for the U.S. Marine Corps. Therefore, emission tests performed on a limited number of off-road diesel engines can provide a fairly complete picture of emissions from the entire population of military off-road sources. The database includes an interface that allows users to view data in onscreen forms or analyze data using built-in reports. The database and interface are intended as resources for anyone interested in examining, filtering, querying, or analyzing the collected data.

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